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**No. 72**



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12 November 1981

# USSR REPORT

## PHYSICS AND MATHEMATICS

No. 72

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## ACOUSTICS

UDC 534.231.1

### CALCULATING SOUND FIELDS IN THE OCEAN BY THE PARABOLIC EQUATION METHOD

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 3, May-Jun 81  
(manuscript received 12 Jun 80) pp 335-340

AVILOV, K. V. and MAL'TSEV, N. Ye., Acoustics Institute imeni N. N. Andreyev,  
USSR Academy of Sciences

[Abstract] An analysis is made of acoustic fields in the ocean based on a model in the form of a liquid layer enclosed by two plane-parallel free boundaries. It is assumed that a strongly absorbing layer close to the lower boundary attenuates reflections. The field of acoustic pressure of a point harmonic source of volumetric velocity is determined for such a model by solving a boundary value problem for Helmholtz's equation. The solution is based on the parabolic equation approximation, that was first proposed by Leontovich and Fok [M. A. Leontovich, V. A. Fok, "Solution of the Problem of Propagation of Electromagnetic Waves Along the Surface of the Earth by the Parabolic Equation Method," ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, Vol 16, No 7, 1946, p 557]. It is shown that this approach is an operator analog of the WKB method, and that it is applicable to the solution of cylindrically symmetric problems for the three-dimensional Helmholtz equation. A numerical example is given. Figures 2, references 8: 5 Russian, 3 Western.  
[214-6610]

UDC 534.222

### NONLINEAR-DIFFRACTION TRANSFORMATION OF ACOUSTIC FIELDS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 3, May-Jun 81  
(manuscript received 3 Jul 80) pp 363-366

ZHILEYKIN, Ya. M. and RUDENKO, O. V., Scientific Research Computing Center,  
Moscow State University imeni M. V. Lomonosov

[Abstract] Processes of propagation of intense acoustic pulses are studied with consideration of nonlinear and diffraction distortions of the initial pulse profile. The analysis is based on a simplified equation of nonlinear acoustics

of finite beams in dimensionless variables. Transverse distribution of intensity is gaussian, and the initial pulse shape conforms to an exponential law. An examination is made of typical signals that arise upon thermo-optical excitation of sound by laser pulses, in explosions, sonic boom and other cases described by a bell-shaped unipolar compression pulse. Figures 4, references 8 Russian. [214-6610]

UDC 681.883.667

# METHOD OF MATHEMATICAL PROGRAMMING IN PROBLEM OF PHASE SYNTHESIS OF ANTENNA ARRAY

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 3, May-Jun 81  
(manuscript received 31 Mar 80) pp 367-372

ZHUKOV, V. B. and SIZIKOV, V. S.

[Abstract] The authors consider the mixed problem of antenna synthesis with respect to assigned requirements for the amplitude response of directionality and known amplitude distribution of excitation, i. e. the problem of phase synthesis of an antenna. This problem is solved by the numerical method of nonlinear programming formulated as a problem of minimization of a criterion functional  $F(\vec{x})$  with constraints  $\{g_i\}$ . The vector  $\vec{x}$  is taken as the vector of intercomponent wave distances and phases of the elements of the antenna array  $x = \{x_0, \dots, x_N, \psi_0, \dots, \psi_N\}$ . The spacing and phases are determined that approximate the characteristic in the vicinity of the main lobe and minimize the side field level for a fixed antenna length. It is shown that a nonequidistant array with intercomponent spacing increasing with distance from the center toward the edges produces a characteristic of directionality with low side lobe level analogously to an equidistant array with amplitude distribution falling off toward the edges. The mathematical programming technique can be used to get a local or global minimum of the functional of mismatch. The method of conjugate gradients with penalty functions guarantees rapid arrival at a local minimum due to absence of strict separability of the criterion functional with respect to the unknown quantities  $x_n, \xi_n$ . Nevertheless, this local minimum yields a solution for the synthesis problem that is satisfactory from the standpoint of practical design of antenna arrays with a reduced side field level. Figures 3, references 4: 3 Russian, 1 Western. [214-6610]

# SCATTERING OF SOUND BY THREE-DIMENSIONAL INHOMOGENEITIES OF UNDERWATER GROUND BOUNDED BY UNEVEN SURFACE

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 3, May-Jun 81  
(manuscript received 7 Aug 80) pp 384-390

IVAKIN, A. N. and LYSANOV, Yu. P., Acoustics Institute imeni N. N. Andreyev, USSR Academy of Sciences

[Abstract] Previous research has dealt with scattering of sound by random fluctuations in the index of refraction of underwater bottom ground with the common assumption that the average density and speed of sound in the bottom are the same as in the nearby water. In this case, scattering is only by three-dimensional inhomogeneities. However, under real conditions in the ocean, the bottom is uneven, and the average acoustic parameters of the bottom ground and of the water are frequently different. In this paper, the authors consider the case where scattering takes place both on three-dimensional inhomogeneities in the ground, and on uneven spots on the surface of the ground. The analysis is based on the first approximation of the method of small perturbations. Experimental and theoretical data are compared for the angular dependence of the coefficient of scattering of sound by the ocean bottom. Figures 5, references 9: 8 Russian, 1 Western.  
[214-6610]

# ATTENUATION OF COHERENT FIELD UPON REFLECTION FROM AGITATED OCEAN SURFACE IN CASE OF SMALL IRREGULARITIES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 3, May-Jun 81  
(manuscript received 12 May 80) pp 411-417

KOZIN, A. B. and CHUPROV, S. D., Acoustics Institute imeni N. N. Andreyev, USSR Academy of Sciences

[Abstract] An analysis is made of the problem of reflection of sound from an uneven surface where the re-radiated field can be represented as the sum of two components: coherent (average field) and scattered. The coherent component is described by the coefficient of reflection of the coherent field, which is equal to the ratio of the amplitude of the wave propagating in the direction of mirror reflection from the undisturbed surface to the amplitude of the incident wave. In the small perturbation approximation the coefficient of attenuation of the coherent is represented as the integral of the product of the energy spectrum of the wave motion multiplied by a weighting function. Analysis of the behavior of this function shows the meaning of approximations for steep and glancing incidence, and gives a better idea of the limits of applicability of

these approximations for a spectrum of completely developed wind-driven agitation in Pierson-Moskovitz form [W. S. Pierson, L. A. Moskovitz, "A Proposed Spectral Form for Fully Developed Wind Seas Based on the Similarity Theory of S. A. Kitaigorodski," J. GEOPHYS. RES., Vol 69, No 24, 1964, pp 5181-5190]. Figures 5, references 4: 3 Russian, 1 Western.  
[214-6610]

UDC 534.232

#### ACOUSTIC FIELD OF ELLIPTICAL CYLINDRICAL RADIATOR SYSTEM IN PRESENCE OF Baffle OF ARBITRARY ACOUSTIC STIFFNESS

Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 27, No 3, May-Jun 81  
(manuscript received 26 Feb 80, after revision 23 Jul 80) pp 418-427

LEYKO, A. G.

[Abstract] The author solves the problem of radiation of sound by a system of arbitrary configuration made up of a finite number of elliptical cylinders with parallel longitudinal axes in the presence of an elliptical cylindrical baffle of arbitrary acoustic stiffness. For two special cases (a flat array with absolutely stiff baffle, and a circular cylindrical array with ideally pliable baffle), the angular distribution is given for the amplitude of the sound field in the wave zone. Figures 5, references 2 Russian.  
[214-6610]

UDC 534.232

#### RADIATION OF SOUND BY PLATE UNDER ACTION OF MOVING HARMONIC FORCES

Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 27, No 3, May-Jun 81  
(manuscript received 10 Jan 80) pp 453-454

MOGILEVSKIY, M. I., Scientific Research Institute of Construction Physics,  
USSR State Committee for Construction

[Abstract] The author considers the problem of sound emission by a thin infinite plate that lies on the lower half-space filled with water. Harmonic forces move over the plate at a given constant velocity. Cases of linear and lumped forces are examined. The solution is found by Fourier transformation with respect to coordinates and time in the equation of motion [I. Ye. Tamm, L. M. Brekhovskikh, "Forced Oscillations of an Infinite Plate in Contact with Water," *ZHURNAL TEKHNIЧЕСКОY FIZIKI*, Vol 16, No 8, 1946, pp 879-888] and determination of the inverse transform. References 3 Russian.  
[214-6610]



# INVESTIGATION OF NONLINEAR OPTIMUM CONTROL PROBLEM BY METHODS OF THEORY OF SINGULAR PERTURBATIONS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 6, 1981  
(manuscript received 22 Dec 80) pp 1295-1298

VASIL'YEVA, A. B. and SAMINSKAYA, M. V., Moscow State University imeni M. V. Lomonosov

[Abstract] An investigation is made of the initial impulses of singular controls in a problem without constraints on controls, using regularization with subsequent asymptotic analysis of the singularly perturbed boundary value problem of Pontryagin's minimum principle. A relation is established between the conditions of construction of boundary layer asymptotics and sufficient conditions of optimality of control of the derivative problem. The case of multidimensional controls is considered. The asymptotic form is constructed in the initial coordinates and in the Gurman-Zelly transformation. References 7 Russian.  
[217-6610]

# SCATTERING OF ACOUSTIC WAVE PACKETS BY THIN-WALLED ELASTIC CYLINDRICAL SHELLS

Tallinn IZVESTIYA AKADEMII NAUK ESTONSKOY SSR: FIZIKA, MATEMATIKA in Russian Vol 30, No 2, Apr-Jun 81 (manuscript received 6 Jan 81) pp 147-158

VEKSLER, N., Institute of Cybernetics, ESSR Academy of Sciences

[Abstract] The author considers the problem of scattering of acoustic wave packets by an empty elastic cylindrical shell of infinite extent in an unbounded ideal compressible fluid. The incident acoustic pressure wave packet has a planar front parallel to the longitudinal axis of the shell. It was assumed that the pressure behavior behind the packet could be arbitrarily assigned. The wave equation is given that is satisfied by the wave field scattered by the shell. Three conditions of contact are assumed on the outer surface of the shell: continuity of radial displacements and stresses, and absence of tangential stresses. Two conditions are assumed on the inner surface of the shell: absence of radial and tangential stresses. The solution is found by integral Fourier transformation with respect to time. The frequency and time dependences are given for the acoustic pressure dissipated into the liquid, and an analysis is made of time dependences for resonant and antiresonant frequencies of excitation by short and long wave packets. The evolution of pressure in the scattered field is described, and its major components are found as well as the relations between them. It is shown that resonances of the frequency dependences occur when an integral number of wavelengths of some normal (Lamb) mode fits on the circumference of the shell. Figures 8, references 24: 8 Russian, 16 Western.  
[254-6610]

## STIMULATED RAMAN SCATTERING OF SOUND IN ANTIFERROMAGNETIC

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 31, No 1, 5 Jul 81 (manuscript received 22 May 81) pp 22-24

LEBEDEV, A. Yu., OZHOGIN, V. I. and YAKUBOVSKIY, A. Yu.

[Abstract] Nonlinearity of low-frequency magnetoelastic waves in magnetic materials is conveniently described in terms of the effective anharmonicity of the elastic subsystem. The simplest manifestations of this nonlinearity are comparatively easily observed, especially in antiferromagnetics. The authors report on the first observation of the more complicated nonlinear dynamic effect of parametric excitation of sound by sound. This effect is a perfect analog of stimulated Raman scattering of light in nonlinear optics. Stimulated Raman scattering of sound has been observed previously in nonmagnetic materials. In this paper the experiments were done at room temperature on a single crystal of hematite with constant magnetic field directed along crystal axis  $U_2$ . Pumping was by transversely polarized ultrasound stimulated on one end of the specimen and propagating along axis  $C_3$ . To set up a traveling wave mode, there was an acoustic damper on the opposite face in the form of a copper plate 1 mm thick connected to the specimen by a micron layer of indium. The transverse sound passing through the damper was picked up by a wide-band lithium niobate acoustic transducer and recorded by a spectrum analyzer. At the threshold strain amplitude of  $(8 \pm 4) \cdot 10^{-7}$  for a magnetic field of 100-400 oersteds, two quasielastic Raman waves were observed on the analyzer screen. When pumping power was exceeded by 3 dB, the amplitudes of these waves reached about 30% of the amplitude of the pumping wave.

References 9: 6 Russian, 3 Western.

[239-6610]

UDC 534.2

## ASYMPTOTIC PROPERTIES OF ONE-DIMENSIONAL ACOUSTIC TURBULENCE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 259, No 1, Jul-Aug 81  
(manuscript received 23 Jun 80) pp 73-75

GURBATOV, S. N. and SAICHEV, A. I., Gor'kiy State University imeni N. I. Lobachevskiy

[Abstract] One-dimensional acoustic turbulence is described by the Burgers equation  $u_t' + uu_x' = \mu u_{xx}''$ ;  $u(x, t = 0) = u_0(x)$ , i.e. by a second-approximation equation with respect to Mach number for intense acoustic waves in a compressible fluid. The most important case is that of large Reynolds numbers where the initially continuous wave is transformed in time to a sequence of sawtooth shock fronts with degeneration of turbulence due to energy dissipation. There are two scales in this case: the external scale  $l(t)$  which is the mean distance between two shock fronts, and the internal scale  $K(t)$  which is the thickness of a shock front. The authors discuss the case of infinite Reynolds numbers ( $\mu \rightarrow 0$ ) where  $K(t) \equiv 0$ . Previous research has shown that the average number of

collisions (confluences of discontinuities) depends on the energy spectrum of the initial field. In this paper an exact solution of the Burgers equation as  $\mu \rightarrow 0$  is used as the basis for analysis of probabilistic and energy properties of acoustic turbulence in times where its properties are appreciably determined by confluence of shock fronts. It is shown that such confluence leads to attenuation of wave energy in accordance with a law  $\langle u^2 \rangle \sim 1/t$  that is much slower than for a harmonic signal without confluence of shock fronts.

References 3: 1 Russian, 2 Western.

[246-6610]

UDC 535.317.1

#### INVESTIGATION OF ANGULAR AND SPECTRAL SELECTIVITY OF HYPERSONIC HOLOGRAM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 6, Jun 81  
(manuscript received 10 Feb 81) pp 1021-1025

VASIL'YEV, M. V., SEMENOV, P. M. and SIDOROVICH, V. G.

[Abstract] A theoretical and experimental study is done on the angular and spectral selectivities of a volumetric reflective hypersonic hologram produced by intense spatially inhomogeneous optical emission accompanying stimulated Mandelstam-Brillouin scattering in a gas. Experiments were done by probing the hypersonic hologram with a light wave with intensity lower than the threshold of stimulated Mandelstam-Brillouin scattering. The density distribution of electrical energy coincides with that of the pumping that stimulates Mandelstam-Brillouin scattering, and the polarization is orthogonal to that of the pumping radiation. The increment of stimulated amplification of the Stokes wave in the investigated substance was determined for different conditions of excitation of stimulated scattering. The angular selectivity of a reflective hypersonic hologram formed in xenon by interference between pumping and Stokes wave was studied by recording the change of reflectivity with variation of the angle of incidence of the probing wave. It was found that the increment of amplification decreases considerably in a range of several centimeters near the boundary of the region of interaction between pumping and Stokes wave, which is in agreement with theoretical predictions. Figures 2, references 6: 4 Russian, 2 Western.

[234-6610]

#### NONLINEAR ACOUSTIC AND PHOTOACOUSTIC PROPERTIES OF PROUSTITE IN TEMPERATURE RANGE OF 4.2-300 K

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 23, No 5, May 81 (manuscript received 9 Oct 79, after revision 24 Nov 80) pp 1395-1399

VIL'CHINSKAS, Sh. P., ZAREMBO, L. K., SERDOBOL'SKAYA, O.Yu. and NOVIK, V. K.,  
Moscow State University imeni M. V. Lomonosov

[Abstract] Studies are done on the nonlinear acoustic properties of proustite with respect to stimulated emission of the second acoustic harmonic of longitudinal waves propagating along directions  $[001]$ ,  $[010]$ ,  $[100]$  in the temperature range

of 4.2-300 K. Axis [010] was selected along one of the planes of symmetry of the crystal. Acoustic absorption and conductivity were simultaneously monitored on the fundamental frequency (15 MHz). An investigation was also made of the influence that preliminary illumination (4000-7000 Å) has on absorption and on the second acoustic harmonic. The single crystals were bars 1 cm long with cross section of 0.25 cm<sup>2</sup>, the end faces being plane-parallel within about 10'. The specimens were annealed at 150-250° C before each measurement cycle. Indium electrodes were sputtered on the end faces of the crystals for conductivity measurements. The dc conductivity was determined from the voltage drop across the specimen by an instrument with  $R_{in} \geq 10^{14} \Omega$  in a measurement field of  $E \leq 1$  V/cm. The measurements were made by a standard pulse technique with rf pulse duration of about 1  $\mu$ s. The temperature and its gradient across the specimen were determined by platinum resistance thermometers with accuracy of  $\pm 0.1^\circ$  C. The influence of defect structure on acoustic parameters of proustite shows up in cumulative absorption with repeated passage through the phase transition of the second kind, and in considerable temperature hysteresis (30 K) of the second harmonic depending on annealing conditions. Figures 3, references 10 Russian.

[225-6610]



IMPULSE CONTROL OF MASSIVE LEG OF WALKING MACHINE

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA  
in Russian No 4, Jul-Aug 81 (manuscript received 11 Sep 79) pp 60-67

VASENIN, V. A.

[Abstract] The problem of designing controls for the motion of the massive leg of a walking machine in the transfer phase is discussed. A model of the leg in the transfer phase is discussed in the form of a plane two-element compound pendulum with specified motion of the point of suspension of the legs in an absolute system of coordinates. The position of the pendulum in the system of coordinates coupled with the point of suspension of the legs is determined by two generalized coordinates: the angle of the thigh with the vertical and the angle of the shin with the extension of the thigh. Equations of motion are presented for a two-element pendulum. Boundary conditions are formed for transfer of the system from some initial state over a specific period of time to a specified final state. The required control effects are sought through impulse equations. The problem is formulated in a space of normal coordinates. A method is suggested for organizing the leg's motion which makes it possible to reduce the amount of information required for designing controls and which improves the accuracy of the fulfillment of terminal conditions in the transfer phase regardless of errors in motion in the supporting phase. The results are given of calculations on a computer for the model of a leg with inertial mass and linear parameters derived from the results of analyzing the geometry of the masses of a human leg. The results demonstrate that the method suggested here for designing controls can be used for controlling real walking machines. Figures 4, references 5 Russian. [251-8831]

**RELATIVE EQUILIBRIUM OF GYROSTAT SATELLITE IN GENERALIZED LIMITED CIRCULAR  
THREE-BODY PROBLEM**

Moscow *PRILADNAYA MATEMATIKA I MEKHANIKA* in Russian Vol 45, No 3, May-Jun 81  
(manuscript received 5 Mar 81) pp 494-503

RUBANOVSKIY, V. N., Moscow

[Abstract] The author considers a system of three bodies  $M_1$ ,  $M_2$  and  $M$ , of which  $M_1$  and  $M_2$  are material points or bodies with spherically distributed masses, and  $M$  is a gyrostator. The centers of gravity of bodies  $M$ ,  $M_1$ ,  $M_2$  are denoted by  $G$ ,  $G_1$ ,  $G_2$ , and their respective masses--by  $m$ ,  $m_1$ ,  $m_2$ . It is assumed that  $m_1, m_2 \gg m$ , and that points  $G_1$ ,  $G_2$  move relative to one another in Keplerian orbits of radius  $\alpha$  with orbital angular velocity  $\Omega$  ( $\Omega^2 = f(m_1 + m_2)\alpha^{-3}$ , where  $f$  is the gravitational constant. It is assumed that the gyrostator rotors spin at angular velocities that are constant relative to the shell of the satellite. The set of relative equilibria of the satellite is studied for the case where  $G$  moves in one of the rectilinear or triangular libration points. A graphic geometric representation of this set is given. Sufficient conditions of stability are derived and analyzed. References 5 Russian.  
[236-6610]

## CRYSTALS AND SEMICONDUCTORS

UDC 535.51:535.328

### PROBLEMS OF MICROTHEORY OF NONLINEAR POLARIZABILITIES OF CRYSTALS, EFFECTS OF SPATIAL DISPERSION

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 45, No 6, Jun 81 pp 898-910

STRIZHEVSKIY, V. L. and CHEPILKO, N. M., Kiev State University imeni T. G. Shevchenko

[Paper presented at the Tenth All-Union Conference on Coherent and Nonlinear Optics, Kiev, 14-17 October 1980]

[Abstract] This paper summarizes the results of the microtheory of nonlinear polarizabilities of crystals and the related theory of spatial dispersion in nonlinear optics based on recent research at Kiev State University. The approach that is used is based on attempts to express nonlinear polarizability in terms of related auxiliary parameters. Calculations are given of Raman spectra in the region of zones of two-frequency excitations of crystals, and the results are shown to compare favorably with available experimental data. Figures 3, references 23: 22 Russian, 1 Western.  
[245-6610]

UDC 535.35

### COHERENT STIMULATION OF EXCITONS IN SEMICONDUCTOR

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 45, No 6, Jun 81 pp 1098-1107

GOLUBEV, G. P., DNEPROVSKIY, V. S., ZIMENKO, Ye. V., POLISSAR, A. V. and CHUMASH, V. N., Moscow State University imeni M. V. Lomonosov, Institute of Applied Physics, MSSR Academy of Sciences

[Paper presented at the Tenth All-Union Conference on Coherent and Nonlinear Optics, Kiev, 14-17 October, 1980]

[Abstract] An experimental study is done on resonant interaction of frequency-tunable ultrashort laser pulses with excitons in semiconductor  $\text{CdS}_{0.4}\text{Se}_{0.6}$  at 77 K and 10 K using a 6G-rhodamine dye laser with passive mode locking. The

laser was pumped by a coaxial flash tube installed directly on a capacitor bank to minimize the inductance of the discharge circuit. The duration of free-lasing pulses did not exceed 1  $\mu$ s. Continuous tuning of the emission wavelength was by rotation of an interference filter in the optical cavity. The tuning range for one filter was 180 Å, and the half-width of the lasing spectrum was about 10 Å. The radiation was focused on the crystal specimen, and the transmitted light was recorded by an FER-2 photoelectronic instrument with time resolution of 30 ns. Part of the incident light diverted by a beam splitter and attenuated by a light filter was also sent to the input slit of the FER-2 as a reference beam. The transmitted and attenuated light were compared to determine the delay characteristics of the pulses. Stimulation of excitons is revealed by the effect of self-induced transparency, i. e. a strong reduction in the absorption of ultra-short light pulses by the semiconductor in the case where pulse duration is shorter than all exciton relaxation times, and the area of the laser pulse is greater than a certain threshold value. Other mechanisms of increased transparency are discussed. Figures 8, references 33: 19 Russian, 14 Western.  
[245-6610]

UDC 621.315.592

#### INFLUENCE OF NONRADIATIVE RECOMBINATION ON LASER CHARACTERISTICS OF DOUBLE InGaAsP HETEROSTRUCTURES

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 15, No 5, May 81  
(manuscript received 15 Jul 80) pp 902-906

GARBUZOV, D. Z., GORELENOK, A. T., CHALYY, V. P. and USIKOV, A. S., Physico-technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] It has been shown in previous research that the inner quantum yield of radiative recombination in the active region of InP-InGaAsP-InP double heterostructures may vary over wide limits from 10 to 80% depending on the conditions of growth. Preliminary investigations indicate that internal luminescence efficiency  $\eta_i$  depends on the level of excitation, and the quantity  $\eta_i$  has a decisive effect on lasing thresholds in the investigated double heterojunctions. The authors check out this hypothesis by a careful study of the way that the outer quantum yield of radiative recombination depends on the excitation level. The specimens were made by liquid epitaxy, and the measurements were done on undoped n-InP-n-InGaAsP-n-InP heterostructures and laser heterojunctions in which the upper p-InP emitter was doped with magnesium. The spectrum of the specimens in the 77-300 K band consisted of a single emission band ( $h\nu_{\max} \sim 0.98$  eV) with half width of 80 meV at 300 K. A correlation is observed between the threshold currents and  $\eta_i$  at 300 K in the material of the active region of these heterostructures. At 77 K, the  $\eta_i$  of the laser diodes approaches 100%, and the threshold current densities are determined by other factors. An investigation is made of the properties of nonradiative recombination channels in the active region of InGaAsP heterostructures. Figures 4, references 5 Russian.  
[241-6610]



**ELECTRON-ELECTRON EXCHANGE IN MANY-VALLEY SEMICONDUCTORS, FINE STRUCTURE OF MANY-EXCITON COMPLEXES IN SILICON**

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 31, No 1, 5 Jul 81 (manuscript received 27 May 81) pp 28-31

PIKUS, G. Ye. and AVERKIYEV, N. S., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] Kaminskiy, Karasyuk and Pokrovskiy resolved the fine structure of emission lines of bound many-exciton complexes in silicon [PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, Vol 33, 1981, p 141]. Their experiments for the first time have opened up the possibility of direct determination of exchange energies in silicon. Pikus and Averkiyev now show that the fine structure of levels of an exciton that is bound on a neutral donor in silicon is due to exchange interaction between electrons of different valleys as well as to electron-hole exchange energies. Figures 2, references 7: 5 Russian, 2 Western. [239-6610]

UDC 535.544:535.417

**OPTICAL DEFORMATION OF SOME CRYSTALS EXPOSED TO CW CO<sub>2</sub> LASER EMISSION**

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 5, May 81 (manuscript received 16 Jul 80) pp 28-29

VOLKOVA, N. V., DARVOYD, T. I., NOSOV, V. B., PETROVSKIY, G. T. and SHATILOV, A. V.

[Abstract] One of the major causes of failure of CW CO<sub>2</sub> lasers is optical deformation of the output windows due to absorption of transmitted radiation. The authors study optical deformation of crystals of KCl, NaCl, KRS-5 (TlBr-TlI), KRS-6 (TlCl-TlBr), ZnSe and BaF<sub>2</sub> exposed to CW CO<sub>2</sub> laser radiation. The crystals were disks 35-64 mm in diameter and 5-13 mm thick with polished surfaces of uniform thickness. Absorption on the lasing wavelength was determined by thermocouple and interference calorimetric methods. Deformation was determined by an interferometric technique. The results are summarized in a table. KRS and KCl crystals showed the lowest level of absorption. It is recommended that steps be taken to reduce the absorption and thermo-optical sensitivity of window materials to minimize distortions. References 12: 8 Russian, 4 Western. [240-6610]

**THEORY OF MANY-PHONON RESONANT RAMAN SCATTERING OF LIGHT IN POLAR SEMICONDUCTORS  
WITH PARTICIPATION OF HOT EXCITONS**

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 23, No 5, May 81 (manuscript received 29 May 80) pp 1265-1275

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[Abstract] When certain polar semiconductors are exposed to light in the vicinity of fundamental absorption, series of narrow lines of scattered radiation are observed on frequencies  $\omega_s = N\omega_{LO}$ , where  $\omega_s$  is the frequency of the stimulating light,  $\omega_{LO}$  is the frequency of longitudinal optical lattice vibrations, and  $N$  is an integer that reaches 7-9. This effect is called many-phonon resonant Raman scattering of light. In this paper, the cross sections of the effect with the participation of hot excitons are numerically calculated, enabling comparison with experimental data. A polar straightband semiconductor is considered with nondegenerate valence and conduction bands at temperatures below the Debye temperature. The contribution to the scattering cross section from hot Mott-Wannier excitons is proportional to the Fröhlich constant  $\alpha$  of interaction of electrons (holes) with LO-phonons. The parameters of CdS and ZnTe are used in the numerical calculations. As a preliminary step, the probabilities of indirect production and indirect annihilation of hot excitons are calculated by two methods: using exact wave functions (with consideration of Coulomb interaction of electrons and holes), and using approximate wave functions to describe virtual intermediate states that belong to the continuous spectrum of exciton energy. It is shown that the results found by the two methods are close at high kinetic energies of generated or annihilated excitons. Formulas previously derived by these authors are also used for calculating probabilities of scattering and decay of excitons. The scattering cross sections  $\sigma(N)$  are found for  $N = 2, 3, 4, 5, 6, 7$  as a function of the primary radiation frequency. It is shown that the values of  $\sigma(N+1)/\sigma(N)$  depend strongly on the ratio of effective masses of the electron and hole, decreasing sharply as this ratio approaches unity. The results are compared with experimental data and with calculations of the contribution of free electron-hole pairs to many-phonon resonant Raman scattering of light. Figures 8, references 27: 7 Russian, 20 Western.  
[225-6610]

# INFLUENCE OF UNIAXIAL PRESSURE ON ENERGY SPECTRUM OF EXCITONS IN GaAs

Leningrad FIZYKA TVERDOGO TELA in Russian Vol 23, No 5, May 81 (manuscript received 22 Jul 80, after revision 25 Nov 80) pp 1407-1410

AL'PEROVICH, V. L., KRAVCHENKO, A. F., PAKHANOV, N. A. and TEREKHOV, A. S.,  
Institute of Physics of Semiconductors, Siberian Department, USSR Academy of  
Sciences, Novosibirsk

[Abstract] Previous research on exciton structure in deformed GaAs has been based on the absorption spectra of thin specimens on a transparent backing, and also on reflection and electrorreflection spectra. Relations have been found for the pressure dependence of positions of the ground state of excitons corresponding to each sub-band of the split valence band. In this paper the energy spectrum of excitons in deformed GaAs is studied from the low-temperature photo-emf spectra of n-GaAs-Al surface-barrier diodes. The specimens were prepared from epitaxial GaAs grown on a semi-insulating GaAs substrate with orientation (110). The specimens were cut as parallelepipeds with dimensions of  $1.35 \times 1.25 \times 10$  mm oriented in direction  $\langle 110 \rangle$  with accuracy of one degree. The photo-emf spectra were measured at different uniaxial pressures along the direction  $\langle 110 \rangle$  for  $\sigma$ - and  $\pi$ -polarizations and compared with the spectrum in an undeformed crystal containing the ground state and first excited state of excitons. It is shown that pressure has no influence on the binding energy of excitons, at least to precision as far as effects associated with overlapping and broadening of exciton lines. Figures 3, references 13: 6 Russian, 7 Western.  
[225-6610]

UDC 546.28:539.2.002.2

# USING INTENSE ELECTRON BEAMS TO ANNEAL SEMICONDUCTORS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 30 May 80) pp 1303-1305

LIDORENKO, N. S., MESYATS, G. A., KYABIKOV, S. V., BONDARENKO, V. D.,  
ZAYTSEVA, A. K., LEBEDEVA, N. I., POLISAN, A. A. and SHEPAK, V. G., Institute  
of High-Current Electronics, Siberian Department, USSR Academy of Sciences,  
Tomsk

[Abstract] The authors consider the feasibility of using an isolated pulse of electron current to anneal an ion-doped layer of silicon. The electron beam is produced by a miniature nanosecond accelerator based on the Marx method with K15-4 ceramic capacitors. The experimental facility produces an electron beam with area of  $3 \text{ cm}^2$  and current density at the anode of about  $1 \text{ kA/cm}^2$  with duration of the pulse at half-amplitude of 30 ns. Pressure in the vacuum diode is  $10^{-2} \text{ mm Hg}$ . The effectiveness of pulsed electronic annealing produces electroactivation of the ion-implanted dopant. In addition, there is an increase in mobility, yielding

an ion-doped layer of high quality. It is concluded that electron-pulse annealing can be substituted for thermal annealing of ion-doped layers. Figures 2, references 7: 5 Russian, 2 Western.  
[221-6610]

UDC 548:537.611.46

#### INVESTIGATING STATIC CHARACTERISTICS OF CYLINDRICAL MAGNETIC DOMAINS ON BOUNDARY OF IMPLANTED REGIONS

Vilnius LITOVSKIY FIZICHESKIY SBORNIK in Russian Vol 21, No 2, Mar-Apr 81  
(manuscript received 11 Jun 80) pp 95-102

POZHELA, I. P., PRANYAVICHYUS, L. I. and URBONAS, D.-T. A., Kaunas Polytechnical Institute imeni A. Sneckkus

[Abstract] An analysis is made of the properties of cylindrical magnetic domains in ferrite-garnet films with ion implantation on the interface between implanted and unimplanted regions, where a threshold arises that acts as a guide for the domains. Previous research has shown that the effect of such a discontinuity formed by chemical etching of channels in ferrite-garnet films is equivalent to a current  $I = M_s \Delta h$  (where  $M_s$  is saturation magnetization and  $\Delta h$  is the depth of the etched layer) that flows along the edge of the projecting section of the film in a direction that corresponds to displacement of the domains from regions of depression toward the perimeter of the boundary of the etched layer. The domains are unable to leave the channel since this would amount to an increase in the total energy of the domain boundary that arises when the domain passes through the lateral surface of the channel. A layer that projects above the surface gives rise to equivalent currents flowing in a direction corresponding to confinement of the cylindrical magnetic domains in the layer. In this paper the authors study the behavior of cylindrical magnetic domains that are produced by ion implantation with analogous projecting and depressed layers. Analytical expressions are derived for the forces of interaction of domains, their depth of penetration beyond the channel region, and the collapse magnetic field. Experiments are done to study domain behavior in regions close to a channel, and in guide channels produced by ion implantation in ferrite-garnet films. The results show that domain behavior in an implanted channel depends on the dose of irradiation as well as on the type and energy of the implanted ions. On the outside of the implanted region, the domains are subjected to repulsive forces that thin the density of domains in this region. The measured width of this zone corresponds to about 20  $\mu\text{m}$  for a ferrite-garnet film with cylindrical magnetic domains 7  $\mu\text{m}$  in diameter. The range of action of this repulsive force is a function of coercivity. Figures 6, references 3: 2 Russian, 1 Western.  
[226-6610]



## ELECTRON-BEAM EXCITED 0.5 GW XeCl LASER

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 6, Jun 81

(manuscript received 24 Jun 80) pp 1323-1325

ADAMOVICH, V. A., BARANOV, V. Yu., SHAKOVSKIY, Yu. B. and STREL'TSOV, A. P.

[Abstract] Experimental studies are done on an excimer laser using a mixture of Ar/Xe/CCl<sub>4</sub> with excitation by an electron beam of about 25 ns duration. The 350 keV electron beam was coupled into the stainless steel laser chamber through aluminum foil 50  $\mu$ m thick. The beam current density was measured by a Faraday cylinder. The composition of the lasing mixture was CCl<sub>4</sub>/Xe/Ar = 1/12.5/1000. Pressure in the laser chamber ranged from 1 to 4 atmospheres. The cavity was formed by an aluminized flat mirror and a lithium fluoride plane-parallel plate with spacing of 40 cm. A calorimeter was used to measure lasing energy, and pulse shape was recorded by an FK-2 coaxial element with time resolution of 0.8 ns, and a 6LOR-04 oscilloscope. The emission spectrum was taken by an STE-1 spectrograph. Maximum lasing energy was attained on a mixture of 1/40/2000. At pressure of 3.5 atm, the energy was about 10 J with power of about 0.5 MW. Average specific energy output was about 7.5 J/liter at efficiency of about 6% relative to the energy invested in the gas. Under the conditions of the experiment, the energy of radiation on infrared transitions of Xe\* did not exceed 40 mJ. Lasing takes place on three lines corresponding to vibrational transitions (0 $\rightarrow$ 1), (0 $\rightarrow$ 2) and (0 $\rightarrow$ 3) of the B $\rightarrow$ X band. Lasing intensity on the first two transitions is about equal. Width of the lasing line is 0.3  $\text{\AA}$  and is weakly dependent on pressure in the 1-4 atm range. Radiation divergence was about  $4 \cdot 10^{-3}$ . This can be improved by using unstable resonators. It is concluded that electron beam pumping is one of the most effective ways of exciting high-pressure excimer lasers. Pumping uniformity in large-aperture lasers can be improved by coupling the electron beam in from both sides. Figures 3, references 8: 1 Russian, 7 Western.

[221-6610]

## FLUID DYNAMICS

UDC 517.946.4

### WIND AND PRESSURE BALANCE EQUATION IN MODEL OF THIN ATMOSPHERE

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA  
in Russian No 4, Jul-Aug 81 (manuscript received 20 Mar 79) pp 11-14

ROZENDORN, E. R.

[Abstract] A balance equation is employed for the purpose of reconstructing or precisely defining a wind field from known pressure and temperature fields. This is necessitated by the fact that in aerological measurements wind speed is determined considerably less precisely than are the temperature and pressure of the air. A balance equation is derived for a model of a closed thin atmosphere discussed in a previous study (Rozendorn, 1981). The curvature of the planet's surface is taken into account. The discussion is based on the application of Monge-Ampere equations to meteorology problems. A uniqueness theorem is obtained for one class of these equations and is proved. Balance equations derived previously applied to limited territories when it was possible to disregard the curvature of the earth's surface or to a closed spherical atmosphere under additional specific conditions. The closed model employed here makes it possible to dispense with formulation of a boundary problem and concern about the precision of determining boundary conditions. References 7 Russian.  
[251-8831]

UDC 533.657.2

### SUPERSONIC FLOW AROUND TRAILING EDGE OF SLENDER AIRFOIL

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСКОY FIZIKI in Russian  
No 3(127), May-Jun 81 (manuscript received 10 Apr 80) pp 36-42

KAZAKOV, A. V., Zhukovskiy

[Abstract] The technique of blending asymptotic expansions has recently been put to effective use in solving problems of the interaction of a boundary layer with an external inviscid flow at high subcritical Reynolds numbers. In this paper, the method is used to investigate supersonic flow around the trailing

edge of an airfoil with low relative thickness. It is assumed that the slender foil is set at a small angle of attack in a uniform flow of viscous gas with characteristic Reynolds number approaching infinity. The problem is formulated for the region of interaction at different values of friction stress in the boundary layer on the upper and lower surfaces of the trailing edge, and the asymptotic solution is given far downstream in scales of the region of interaction. Figures 3, references 10: 3 Russian, 7 Western.  
[237-6610]

UDC 53.091

**CONVERGENCE AND REGULARIZATION OF DISCRETE EDDY METHOD IN INVESTIGATION OF DETACHED FLOWS**

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI in Russian No 6, Jun 81 (manuscript received 30 Oct 80)  
pp 74-78

KUCHUGURA, A. K., RYSEV, O. V. and SELEZOV, I. T., Institute of Hydromechanics, UkrSSR Academy of Sciences

[Abstract] The problem of interaction of a soft permeable shell with a liquid leads to the necessity of determining the hydrodynamic characteristics of the shell in a flow of ideal incompressible fluid with formation of surfaces of tangential discontinuity of velocities. Numerical realization of the method involves considerable difficulties. In this paper, an analysis is made of a discrete computational scheme, and an algorithm of regularization is used for solving the problem. An axisymmetric shell is considered that is formed by a frustum of a cone that widens from the leading edge (input for the flow) and then terminates in a spherical dome so that the radius of the midsection is greater than the radius of the inlet opening. The midsection is appreciably removed from the inlet edge, and flow is treated as detached with formation of an eddy zone behind the shell with onset in the mid region. Regularization is by an algorithm of differentiation of a presmoothed function. Results of numerical calculations are given for the drag and the velocity field behind the shell. Figures 3, references 8: 7 Russian, 1 Western.  
[235-6610]

UDC 621.378.335

RADIATIVE RECOMBINATION REACTIONS SUITABLE FOR USE IN ELECTRONIC PHOTOJUNCTION LASERS (REVIEW)

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 26, No 6, Jun 81  
(manuscript received 4 Jul 80) pp 881-903

KOCHELAP, V. A. and IZMAYLOV, I. A., Institute of Semiconductors, UkrSSR Academy of Sciences, Kiev

[Abstract] The state of the art in radiative recombination reactions suitable for lasers is surveyed on the basis of studies, especially experimental ones, made since 1964 with particular emphasis on the chemiluminescent nature of the processes and the role of electron states in them. Four mechanisms of recombination pumping are reviewed: emission of light due to biparticle (atoms, radicals, molecules) collisions, emission of light by electronically excited molecules from bound vibrational-rotational states in equilibrium with dissociated states or by electronically excited molecules at bound levels not in equilibrium with dissociated states, and emission of light by nonreacting molecules or atoms excited with the recombination energy. The survey covers radiative recombination reactions involving atoms of group-VI elements ( $O+O$ ,  $S+S$ ,  $Se+Se$ ,  $Te+Te$ , and  $S+O$ ) and of group-VII elements ( $Cl+Cl$ ,  $Br+Br$ ,  $Br+Cl$ ,  $I+Cl$ , and  $I+I$ ). These reactions are evaluated comparatively with respect to the concentration dependence and the temperature dependence of the inverse population and of the gain, from the standpoint of applicability with various methods of inversion. On the basis of available data, recombination of sulfur atoms is most promising at temperatures of the order of 1000 K with any method of inversion. Recombination of halogen atoms, although yielding a lower gain, requires lower temperatures (500-700 K) with optical, shockwave, or thermal pumping. Figures 3, tables 2, references 88: 35 Russian, 53 Western.  
[243-2415]



**LASER-STIMULATED THERMOCHEMICAL EFFECTS**

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 45, No 6, Jun 81 pp 1018-1042

BUNKIN, F. V., KIRICHENKO, N. A. and LUK'YANCHUK, B. S., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Paper presented at the Tenth All-Union Conference on Coherent and Nonlinear Optics, Kiev, 14-17 October, 1980]

[Abstract] A survey of the literature on laser thermochemistry in homogeneous and heterogeneous systems. It is shown that laser stimulation of chemical effects involves strong Arrhenius dependence of rate constants on temperature, nonisothermicity of processes (which adds temperature as a new degree of freedom), thermal "feedback" in the system that may be selective and realizable in a given reaction channel, and a controllable transfer factor (laser power or intensity) with respect to the thermal feedback channel. The specifics of laser emission such as monochromaticity, coherence and high power make themselves felt in laser thermochemistry. For example the capability of concentrated energy input enables large localized deviations from thermodynamic equilibrium in the system. Monochromaticity produces the thermal feedback effect that enables observation of special types of dynamic behavior. Coherence is conducive to space-time synchrotronization of optothermochemical processes leading to peculiarities of nonlinear scattering of light in the medium where the chemical reaction takes place. Possible applications of laser thermochemistry include control to maximize product yield in organic synthesis, laser-chemical treatment of metals and semiconductors in various atmospheres in microcircuit technology, synthesis of surface compounds (oxides, nitrides, borides and so on), and laser-controlled diffusion processes. Figures 17, references 72: 66 Russian, 6 Western.  
[245-6610]

**STIMULATED EMISSION OF ULTRASHORT PULSES IN NEODYMIUM LASER WITH RAPIDLY SWITCHED PLASMA MIRROR**

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 33, No 12, 20 Jun 81 (manuscript received 4 May 81) pp 630-633

MALKOV, A. N., PROKHOROV, A. M., FEDOROV, V. B. and FOMENKOV, I. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A report on observation of picosecond laser pulses (duration about 24 ps) in a neodymium glass laser with plasma mirror. The investigated single-channel laser was made up of four GOS-1000B illuminators, the first being placed in a telescopic optical cavity. The plasma mirror was formed on the surface of a flat graphite target in air at the focus of a lens with focal length of

50 cm located behind the last illuminator. Rapid initiation of the reflecting plasma on the target leads to Q-switching and stimulated emission of a monopulse with structure characteristic of mode locking. The monopulse consists of two or three trains of ultrashort pulses. The emission of these pulses is studied with picosecond time resolution by the Agat-SF optoelectronic chamber. Photographs of the near and far zones of the radiation were obtained as well as streak camera pictures of plasma motion. The high brightness of plasma luminescence on the surface of the target shows that principal absorption of laser emission energy by the plasma takes place near the target. Figures 2, references 4: 3 Russian, 1 Western.  
[238-6610]

UDC 621.373:535

#### CALCULATING FREQUENCY SPLITTING IN ACTIVE RING CAVITY

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 6, Jun 81  
(manuscript received 14 Apr 80) pp 1062-1066

ISHCHENKO, Ye. F. and RESHETIN, Ye. F.

[Abstract] Diffraction frequency splitting of opposed waves is calculated and analyzed over a wide range of resonator parameters based on numerical solution of the problem of an electromagnetic field in a traveling-wave ring cavity with an iris and a thin focusing element. It is assumed that the cavity includes a layer of weakly nonlinear active medium. The calculation is based on representing the cavity as an infinite periodic structure. It is shown that the maximum frequency splitting for any fixed volume of medium decreases with increasing Fresnel number, even though not monotonically. The degree of this reduction is minimum when the product of the power of the focusing element multiplied by the length of a period of the cavity is zero, and is maximum when this product is equal to 2 (confocal cavity). In the former case, maximum frequency splitting decreases by no more than a factor of ten with an increase in Fresnel number by 0.5, while the reduction in the latter case is  $e^{2\pi}$  (a factor of about 535.5) with the same increase in Fresnel number. The curve for maximum frequency splitting as a function of relative optical power depends on Fresnel number, and is fairly smooth with a single minimum near the confocal configuration at low Fresnel numbers, then with increasing Fresnel numbers new minima begin to show up corresponding to relative optical powers of 1, 3, 4/3, 8/3, 2/3, 10/3 and so on. These curves are relatively symmetric with respect to the confocal arrangement. The proposed method of calculating frequency splitting is effective both with and without a focusing element. Figures 5, references 8 Russian.  
[234-6610]

# UNSTEADY STIMULATED EMISSION OF SECOND HARMONIC BY ULTRASHORT LASER PULSE WITH PHASE MODULATION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 6, Jun 81  
(manuscript received 11 Nov 79, after revision 23 Jan 81) pp 1075-1078

TAGIYEV, Z. A.

[Abstract] Research on the unsteady process of multiplication of laser frequencies is of considerable interest in connection with generation of ultrashort pulses in the ultraviolet range. Most of the previous theoretical work on this problem has been done in the first approximation of dispersion theory, i. e. with consideration of only the group delay of the interacting pulses. This paper gives the results of analysis of frequency multiplication of an ultrashort optical pulse with phase modulation in the second approximation of dispersion theory. Stimulation of the second harmonic is considered in a spectral approach. It is shown that phase modulation may increase the efficiency of conversion with no change in the energy of the fundamental radiation. Thus in some cases an increase in the energy of the second harmonic is to be expected with phase modulation of ultrashort laser pulses. Figures 4, references 10: 9 Russian, 1 Western.  
[234-6610]

UDC 621.378.3

# CONTROLLING POLARIZATION OF RADIATION OF LASER WITH ANISOTROPIC CAVITY

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 6, Jun 81  
(manuscript received 31 Jul 80) pp 970-974

DEM'YANTSEVA, S. D. and TABARIN, V. A.

[Abstract] A theoretical analysis is made of the transient process that leads to settling of steady-state polarization of emission from a laser in which the cavity contains an active medium, a Faraday rotator and a nonideal linear polarizer. The authors determine the degree of influence that anisotropy of cavity losses has on the duration of the transient process and the angle of rotation of the direction of linear polarization of emission. It is shown that in steady-state operation the maximum deviation of the direction of steady-state polarization from the initial direction depends only on the anisotropy of the optical cavity. A numerical estimate is given for lasers with Brewster windows. Figures 3, references 12: 8 Russian, 4 Western.  
[229-6610]

# INFLUENCE OF RESONANT MECHANISM OF PHOTOCHROMISM ON FREQUENCY SHIFT OF STIMULATED EMISSION OF CW DYE LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 6, Jun 81  
(manuscript received 9 Jun 80) pp 975-979

KABANOV, V. V. and RUBANOV, A. S.

[Abstract] One of the causes of instability of the frequency of stimulated emission of a cw dye laser under conditions of single-frequency lasing is the dependence of the frequency shift of stimulated emission on pumping parameters. Generally speaking, conditions of optical pumping require consideration of non-linearity of the interaction between radiation and the dye solution, and also accounting for other effects to evaluate the contribution that each of them makes to displacement of the lasing frequency. In this paper a theoretical estimate is made of the shift in emission frequency in a laser with free-flow jet due to a resonant mechanism. An investigation is made of the way that this shift depends on the pumping radiation parameters with consideration of light-induced changes in the optical properties of the dye solution. Contributions to the lasing frequency shift due to resonant and thermal nonlinearity are compared. It is shown that the main contribution to displacement of radiation frequency is from the resonant change in the index of refraction of the dye. The conditions of interaction between the radiation and dye solution are responsible for the weaker influence of the thermal mechanism. As the time of interaction of the pumping radiation increases, the component of the frequency shift due to thermal action increases, until it becomes comparable with the resonant component at about  $10^{-5}$  s. On the other hand, the magnitude of the resonant shift depends on the frequency of the stimulated mode, and the contribution due to resonance decreases toward the edges of the amplification line. References 4 Russian. [229-6610]

UDC 621.373.029.67

# FM RADIATION AMPLIFICATION IN SUPERREGENERATIVE LASER AMPLIFIER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 6, Jun 81  
(manuscript received 28 Apr 80) pp 1117-1119

LEDNEVA, G. P.

[Abstract] Conventional regenerative laser amplifiers cannot take advantage of the interference immunity of FM communication because they amplify only the emission on natural frequencies of the optical cavity. To amplify weak FM signals, a superregenerative laser amplifier can be used since its gain is less sensitive to a change in the frequency that is being amplified. Superregenerative amplification can be accomplished by using a laser with a periodically Q-switched cavity.



Linear and nonlinear amplification are distinguished just as in regenerative devices. The linear operation in a superregenerative amplifier may be of the order of  $1 \mu s$ . The author considers amplification of a pulse signal with linear frequency modulation in a superregenerative laser amplifier with a ring cavity in linear operation. Dispersion of the active medium is disregarded. An expression is found for the intensity of the amplified pulse in the case of strong modulation. Figure 1, references 5 Russian.  
[229-6610]

# DETERMINING VIBRATIONAL TEMPERATURES AND GAIN IN GASDYNAMIC CO<sub>2</sub> LASER WITH ADDITIVES OF CO AND NO: I. METHODS OF THEORETICAL AND EXPERIMENTAL DETERMINATION OF VIBRATIONAL TEMPERATURES

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 17, No 3, May-Jun 81  
(manuscript received 25 Sep 80) pp 83-93

DOROSHENKO, V. M., KUDRYAVTSEV, N. N. and NOVIKOV, S. S., Moscow

[Abstract] The vibrational temperatures of asymmetric and collective (symmetric and deformation) modes of CO<sub>2</sub> are measured, and consequently the populations of the upper 00<sup>0</sup>1 and lower 10<sup>0</sup>0 laser levels of carbon dioxide when nitrogen in the mixture 0.1CO<sub>2</sub> + 0.4N<sub>2</sub> + 0.5He is replaced with carbon monoxide or nitric oxide. The weak-signal gain on the laser transition (00<sup>0</sup>1→10<sup>0</sup>0) is reconstructed from laser level populations. Vibrational temperatures of CO<sub>2</sub> are determined from measurements of the intensity of spontaneous infrared emission in the 4.3  $\mu m$  and 2.7  $\mu m$  bands, and the gain is measured at the same time by a CO<sub>2</sub> probe laser. Vibrational temperatures of CO and NO are determined from the intensity of infrared radiation in the 4.7  $\mu m$  and 5.3  $\mu m$  bands respectively. The results are compared with theoretical calculations. Figure 1, tables 2, references 69: 30 Russian, 39 Western.  
[228-6610]

# CYCLOTRON RESONANCE MASER WITH BACKGROUND PLASMA

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 80, No 6, Jun 81 (manuscript received 2 Oct 80) pp 2198-2209

GAPONOV-GREKHOV, A. V., GLAGOLEV, V. M. and TRAKHTENCERTS, V. Yu., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] An analysis is made of the effect of energy accumulation in quantum electronic devices that use a nonlinear element to maintain a high excitation threshold during the cumulative process with sudden release of the energy in the form of emission after saturation is reached. An electronic device of this type is considered that is based on a magnetic trap with energetic electrons placed in a quasioptical cavity. The prototype at the low limit of plasma density is the cyclotron resonance maser. It is shown that direct coupling of radiation

out of a region with high index of refraction into vacuum is possible only in a rarefied plasma where the condition  $\omega_{pl} \leq \omega \leq \Omega_L$  is satisfied. Here  $\omega_{pl}$  is the Langmuir frequency in the center of the trap,  $\omega$  is the frequency of the emission, and  $\Omega_L$  is the gyrofrequency of electrons in the central cross section of the system. A theoretical analysis is made of the effects in such a device, and it is shown that a new type of plasma generators of electromagnetic wave forms could be based on energy accumulation in the form of fast electrons with explosive conversion of this energy to electromagnetic radiation. An example of such a generator in nature on a gigantic scale can be seen in the Van Allen radiation belts. The mathematical model of the device is based on a magnetic trap that is enclosed in a resonant cavity and contains a two-component plasma consisting of a dense, cold equilibrium plasma with anisotropic additive of hot electrons. It is assumed that the density of the equilibrium plasma is much greater than that of the hot electrons, and that the product of density multiplied by temperature is much lower for the cold component of the plasma than for the hot electrons. On the basis of the results, an interpretation is given of some effects observed in laboratory experiments. References 9: 6 Russian, 3 Western. [223-6610]

UDC 621.278.325

#### COHERENT PROPERTIES OF LTIPCh LASERS WITH MODE SELECTION

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 7 Jul 80) pp 1212-1214

VAYTKUS, Yu., GAUBAS, E. and YARASHYUNAS, K., Vilnius State University imeni V. Kapsukas

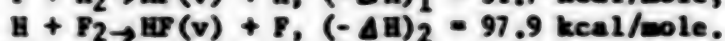
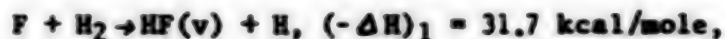
[Abstract] Series-produced lasers of the LTIPCh type have good characteristics--recurrence rate and radiation frequency conversion efficiency--but are not suitable for holographic purposes because of low degree of coherence, and fluctuations of intensity and pulse duration. The authors consider the feasibility of improving this neodymium-doped YAG tunable-frequency laser by increasing emission pulse coherence, and also propose a method of evaluating laser coherence. Increasing the length of the cavity of the LTIPCh-y laser to 77 cm and adding a diaphragm with diameter of 2 mm (diameter of the active element is 5 mm) improved the radiation pattern by a factor of two. Longitudinal mode selection was achieved by a resonant reflector used as the output mirror of the cavity. This reflector was comprised of plane-parallel glass plates 3-4 mm thick with air space of 13 mm. The efficiency of mode selection was evaluated by dynamic holography involving self-diffraction of light by dynamic gratings. It was found that mode selection leads to single-frequency emission of the radiator characterized by an increase in coherence length from 0.2 to 2 m and an improvement in the general degree of coherence by a factor of 5-8 with good reproducibility of pulses with respect to intensity on a radiation wavelength of 1064 nm. The laser produces output pulses with power density of 2-5 MW/cm<sup>2</sup> with degree of coherence approaching unity. The proposed modifications make this laser usable for holographic applications. Figures 2, references 12: 7 Russian, 5 Western. [221-6610]

## RING MODEL OF CW HF CHEMICAL LASER WITH CHAIN MECHANISM OF EXCITATION

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 8 Dec 78) pp 1273-1275

STEPANOV, A. A. and SHEGLOV, V. A., Physics Institute imeni P. N. Lebedev,  
USSR Academy of Sciences, Moscow

[Abstract] An analysis is made of the energy capabilities of a CW HF chain laser using a cylindrical nozzle module with radial gas flow. The chain mechanism of excitation was



The cylindrical nozzle module includes a large number of small plug nozzles with alternating jets of helium-diluted oxidant and fuel. The cavity is formed by ring-shaped mirrors. Analysis of stimulated emission in the proposed laser was based on solution of two-dimensional Navier-Stokes equations in the boundary-layer approximation supplemented by processes of chemical, vibrational and radiation kinetics. Mixing of flows was taken as laminar. The parameters taken as fixed in the calculations were the radius of the nozzle module, the heights of the plug nozzles, pressure at the nozzle tip, degree of helium dilution of the oxidant, degree of dissociation of fluorine, and also the pressure, temperature and velocity of the oxidation and reduction streams. It was found that the ring geometry is conducive to conditions of neutralization of the thermal effect in the cavity, and thus can solve the problem of "thermal" blocking of the supersonic channel. The proposed type of laser can give a chemical efficiency of 10%, specific laser energy of 1 kJ/g and normalized laser power of 1 kW/cm<sup>2</sup>. The chain mechanism of excitation permits pressures up to 15-25 mm Hg in the cavity region, which is important for solving the ejector problem. Figures 2, references 6: 3 Russian, 3 Western.

[221-6610]

## INVESTIGATING PROCESS OF ESTABLISHMENT OF INDUCED MODE-LOCKING IN SOLID-STATE CONTINUOUS-WAVE LASERS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 16 May 80) pp 1292-1294

KORNIYENKO, L. S., KRAVTSOV, N. V., SUSOV, A. M. and SIDOROV, V. A., Scientific Research Institute of Nuclear Physics at Moscow State University imeni M. V. Lomonosov

[Abstract] An experimental study is done on the transient state of induced axial mode-locking in a neodymium-doped YAG CW laser. The laser had an optical delay line with effective cavity length of 23 m. Two garnet crystals 5 mm in diameter

and 50 mm long were connected in series and pumped by DNP 6/60 flashlamps. To eliminate mode selection, the end faces of the crystals were beveled at an angle of  $1.5^\circ$  to the optical axis and coated to reduce reflection. Induced mode locking was produced by electro-optic modulators based on  $\text{LiNbO}_3$  crystals. The laser emission was a series of ultrashort pulses with recurrence rate of 6.52 MHz. The results of the studies showed that the transient process is quite prolonged with duration depending on the method of modulation. The frequency of intensity modulation during the transient process is close to the frequency of relaxational oscillations of the investigated laser. The process of damping of mode locking when the modulating voltage is switched off is analogous. The transient process is more pronounced for amplitude modulation, and lasts several tens of microseconds, while the process lasts for only a fraction of a microsecond in the case of phase modulation. The maximum mismatch for which the duration of the ultrashort pulses doubles for a given cavity length is 1 kHz. The time of establishment of mode-locking measured in the experiments with a phase modulator was about 2.6 ms, while the analogous time for experiments with an amplitude modulator was about 1.2 ms for the same phase shift on the electro-optical crystal. Figure 1, references 8: 3 Russian, 5 Western.

[221-6610]



UDC 533.95+538.4

CALCULATING EIGENFUNCTIONS AND EIGENVALUES OF IDEAL AND RESISTIVE MODES IN PLASMA

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 15: VYCHISLITEL'NAYA MATEMATIKA I KIBERNETIKA in Russian No 2, Apr-Jun 81 (manuscript received 2 Jun 80) pp 13-17

SHAGIROV, E. A.

[Abstract] The author considers the problem of theoretical investigation of macroscopic instability of a plasma column in a tokamak. The properties of ideal MHD stability of cylindrical systems are usually determined by some procedure for solving a one-dimensional second-order equation for eigenfunctions and eigenvalues. For resistive modes one can get a system of two one-dimensional time equations. This paper gives a procedure for solving them and the results of calculation of eigenfunctions in the approximation of small  $\beta$  ( $\beta \sim \epsilon^2$ ). The problem of studying MHD stability of toroidal systems is much more complicated than the cylindrical case. A method is proposed that uses a direct form of iterations where the linearized system of MHD equations is solved as a modified problem with initial conditions. Results are given of calculation of the eigenfunctions of an instability in a torus by this method. The analysis is based on consideration of a certain number of axially symmetric configurations for which the stability boundaries and increments are defined, Figures 4, references 7: 3 Russian, 4 Western.  
[210-6610]

UDC 533.9.08

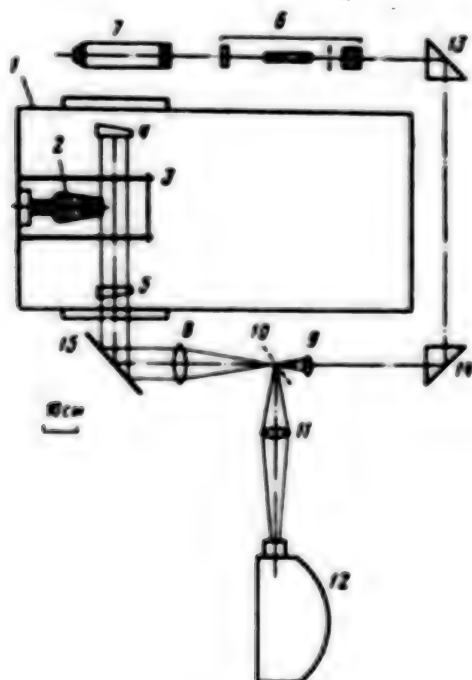
INTERFEROMETRIC STUDY OF COMPRESSION REGION OF MAGNETOPLASMA COMPRESSOR

Moscow FIZIKA PLAZMY in Russian Vol 7, No 3, May-Jun 81 (manuscript received 21 Apr 80, after revision 21 Oct 80) pp 523-528

ASTASHINSKIY, V. M. and KOSTYUKOVICH, Ye. A., Institute of Physics, BSSR Academy of Sciences

[Abstract] A magnetoplasma compressor is a coaxial system that produces plasma streams compressed by an azimuthal magnetic self-field. Description of the processes that take place in this device requires determination of the time-variable

parameters of the plasma flux. Spectroscopic studies of the compression region have shown the time behavior of the major plasma parameters along the axis. In this paper the authors study the compression region of a magnetoplasma compressor by high-speed interferometric motion picture photography with visualization of the field. The experiments were done on a gas magnetoplasma compressor, which is shown with the interferometer in the diagram. The discharge device consists of an inner electrode with axial hole (diverter) and an outer electrode formed by 12 rods symmetrically arranged in a circle. The power supply was a capacitor bank with energy of 30 kJ. Energy input to the discharge is about 20 kJ, 60% going to the first half-period of the current when the cathode is the inner electrode. The pressure of the working gas (air) was 1 mm Hg, and the time resolution of the camera was no worse than 1  $\mu$ s. The spatial distribution of electron concentrations is found for different stages of the process. Maximum concentration of  $2 \cdot 10^{18}$  cm<sup>-3</sup> is observed on the axis of the plasma stream. The velocity of motion of the plasma boundary toward the axis of the discharge is determined as well as the gradients of electron concentration in the compression region.



[FIGURE CAPTION] 1--magnetoplasma compressor chamber; 2, 3--discharge device; 4, 5--interferometer mirrors; 6--ruby laser; 7--LG-78 gas laser; 8, 9--telescope; 10--semitransparent mirror; 11--matching objective lens; 12--high-speed camera; 13, 14--rotating prisms; 15--rotating mirror.

Figures 6, references 10: 8 Russian, 2 Western.  
[227-6610]

## NONRESONANT MECHANISM OF ION HEATING BY MHD WAVES

Moscow FIZIKA PLAZMY in Russian Vol 7, No 3, May-Jun 81 (manuscript received 4 Apr 80, after revision 1 Jul 80) pp 639-645

VAYNSHTEYN, S. I. and SHUKHMAN, I. G., Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, Siberian Department, USSR Academy of Sciences

[Abstract] An examination is made of the mechanism of accelerating and heating of particles by MHD waves. The effective temperature of these waves is  $T_{\text{eff}} = W/\Delta k^3$ , where  $W$  is energy density, and  $\Delta k^3$  is the characteristic phase volume in the space of wave numbers. Since  $\Delta k$  is much smaller than the ratio of the ion cyclotron frequency to the Alfvén velocity,  $T_{\text{eff}}$  is relatively high, and usually exceeds both the plasma temperature and the temperature of other modes of oscillation. In previous research, MHD waves have been invoked to explain peculiarities in the solar wind and magnetosphere, based on resonant mechanisms of wave interaction with particles and Fermi acceleration due to particle reflection from magnetic inhomogeneities. In this paper the authors consider plasma heating by MHD waves, i. e. acceleration of ions at the thermal velocity (much lower than the Alfvén velocity). Such particles cannot interact resonantly with MHD waves. It is shown that this interaction involves the low-frequency "tail" of the function of magnetic perturbations. Specific mechanisms leading to such a "tail" are suggested, and astrophysical applications are discussed: heating of the solar corona, and acceleration of thermal ions in the earth's magnetosphere. Figure 1, references 12 Russian.  
[227-6610]

PARAMETRIC EXCITATION OF MOLECULAR OSCILLATIONS, LASER-CHEMICAL REACTIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 45,  
No 6, Jun 81 pp 1007-1017

AMEL'KIN, S. V. and ORAYEVSKIY, A. N., Physics Institute imeni P. N. Lebedev,  
USSR Academy of Sciences

[Paper presented at the Tenth All-Union Conference on Coherent and Nonlinear  
Optics, Kiev, 14-17 October, 1980]

[Abstract] In previous research on excitation of molecules by laser radiation, parametric interaction of modes in the molecules has been suggested in connection with interpretation of the photochemical action of laser emission. In the proposed mechanism of excitation, the laser excites molecular oscillation with frequency  $\omega_0$  that is resonant with the emission frequency:  $\omega_L = \omega_0$ . Due to nonlinear intermode coupling, the energy may be transferred from the resonant mode to other modes of the molecule. The excitation of other modes becomes quite effective if resonance conditions exist between frequencies of the different oscillations. The simplest of these conditions is  $\omega_0 = \omega_1 + \omega_2$ , where  $\omega_1$  and  $\omega_2$  are the resonant frequencies of two other modes that are excited by energy transfer from mode  $\omega_0$ . In this paper the authors restrict themselves to quantum analysis of the problem based on a model in which the interacting modes of the molecule are taken as harmonic oscillators in the simplest degenerate case of resonant parametric interaction of two modes where  $\omega_0 = 2\omega_1$ . A more precise model is considered in which the anharmonicity of the molecule is taken into consideration by accounting for the actual quantum structure. In this model the molecule is characterized by a set of discrete vibrational levels corresponding to excitation of certain vibrational modes. Nonlinear properties are examined on the basis of experimental data for molecules that take part in initiation of chemical reactions. Experiments are described that indirectly confirm the mechanism of parametric excitation in molecules. Figures 6, references 14: 10 Russian, 4 Western.  
[245-6610]



# EXCITATION AND DEACTIVATION OF METASTABLE STATE $\alpha^3\Pi$ OF CO MOLECULE IN DISCHARGE IN MIXTURES OF He-CO, He-CO-Xe AND He-CO-O<sub>2</sub>

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: FIZIKA, KHIMIYA in Russian No 10, Issue 2, May 81 (manuscript received 20 Dec 80) pp 123-126

IVANOV, Ye. Ye., IONIKH, Yu. Z., PENKIN, N. P. and CHERNYSHEVA, N. V.

[Abstract] The lowest and most highly populated of the excited electronic states of carbon monoxide is  $\alpha^3\Pi$ . This state can be important in processes such as step-by-step excitation and ionization as well as chemical reactions that take place in CO laser plasma. In this paper the authors study processes of population and annihilation of  $\alpha^3\Pi$  in a positive glow discharge column in mixtures of He + (0.1-3)% CO, He + 3% CO + 0.3% O<sub>2</sub>, He + 3% CO + 1% Xe and He + 0.8% CO + 3% Xe. Measurements were made at total gas pressures from 0.5 to 8 mm Hg and discharge current from 10 to 80 mA. The gas flowrate through a discharge tube 30 mm in diameter and 250 mm long as measured by the pressure differential across a calibrated capillary varied with pressure from 0.1 to 1.2 m/s. Electric field intensity and electron concentration in the discharge were measured by a probe method. The gas temperature in the discharge was determined by solving the equation of heat conduction. The fraction of electron energy dissipated as heat was determined from the calculated electron energy distribution function. Vibronic bands of the Cameron system of CO with forbidden rotational structure were recorded by a chart plotter, and the area under the curve was interpreted as the relative brightness of the band. Conversion to absolute brightness was done by using standard light sources. The rate constants of excitation of  $\alpha^3\Pi$  are found as a function of the normalized electric field strength  $E/N$  (where  $N$  is total particle concentration) in a range of  $(0.6-4) \cdot 10^{-16}$  V·cm<sup>3</sup>. The theoretical values found by integrating the calculated electron energy distribution function and the known cross section agree satisfactorily with experimental data. This confirms the validity of the proposed model of excitation and annihilation of the metastable state  $\alpha^3\Pi$  of carbon monoxide. Figures 2, references 8: 2 Russian, 6 Western. [230-6610]

UDC 525.373.2

## SOME PROBLEMS OF KINETICS OF FORMATION OF INERT GAS HALIDE EXCIMERS

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 3, May-Jun 81 (manuscript received 2 Nov 80) pp 455-460

GRINCHENKO, B. I., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] In previous papers, the author has examined a new channel of formation of excimer molecules of inert gas halides in reactions of charge exchange of positive ions ( $RX^+$ ) with negative ions ( $X^-$ ) ( $R$  is an inert gas,  $X$  is a halide)

[see TEPILOFIZIKA VYSOKIKH TEMPERATUR, Vol 17, No 3, 1979, p 645; PIS'MA V ZHURNAL TEKHNIЧЕСKOHY FLIKI, Vol 5, No 18, 1979, p 1101]. In this paper, the kinetic model developed in the author's previous research is used as a basis for a new approach to description of the principal processes of formation of excimer molecules of the RX and R<sub>2</sub>X types in reactions of recombination of positive molecular ions RX<sup>+</sup> with negative ions X<sup>-</sup>. The analysis is based on a model of a plasma produced when inert gases doped with trace amounts of a halide-containing substance are ionized by an intense electron beam or a pulsed electric discharge. The theory takes consideration of ionic-molecular reactions of formation of RX<sup>+</sup>, the particulars of formation of excimer RX\* molecules upon recombination of ions of RX<sup>+</sup> and X<sup>-</sup> in reactions of the type  $RX^+ + X^- \rightarrow RX^* + X$ , and the conditions of efficient formation of these molecules in the given reactions. A comparison of the proposed kinetic model with experimental data shows that it satisfactorily describes processes in inert gas halide lasers, Figure 1, references 18: 16 Russian, 2 Western.  
[224-6610]

## NUCLEAR PHYSICS

UDC 539.1.074.8;539.1.076

### 'PLASMA FOCUS' AND METHODS OF MEASURING NEUTRON FLUX GENERATED BY SHORT-LIVED PLASMA

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA AKADEMII  
NAUK SSSR: NEYTRONNO-FIZICHESKIYE ISSLEDOVANIYA in Russian Vol 127, 1980 pp 89-97

VOLOBUYEV, I. V., GRANATKIN, B. V., deceased, and ISAKOV, A. I.

[Abstract] The PF-30 plasma focus designed and built by the authors at the Physics Institute of the USSR Academy of Sciences consists of two cylindrical electrodes, the space between which is filled with deuterium at 1 to 10 mm Hg. About 20 kV is applied to the electrodes to ultimately produce a dense plasma of about 0.1 cm with a density of  $10^{19}$ - $10^{20}$  ions/cm<sup>3</sup> and a temperature of 3 to 5 KeV. The operation, design considerations and parameters of the discharge chamber, the capacitor bank powering the unit (25 kV working voltage, total capacitance of 96 microfarads, 30 kJ maximum energy), the discharger and the firing circuitry are described. The optimization of plasma focus operation is based on its neutron yield. At a capacitor bank voltage of about 16 kV, the neutron yield reaches  $5 \cdot 10^8$  neutrons/flash. An oscilloscope determination of the time between the initiation of the discharge and the formation of the plasma focus shows that the current reaches a maximum of 480 kA 2.5 microseconds after the start of the discharge for the maximum neutron yield. The discussion of the detectors for recording the neutron flux from pulsed plasma sources of this type notes that silver foil is preferred for the registration of the neutrons from D-D and D-T reactions. The parameters and operation of a scintillation detector with NaI crystal as well as precise methods of neutron flux measurement for D-T reactions and photomultiplier detectors in which detection is based on the laws governing nonsteady-state diffusion are also treated. Expressions are given for the determination of the number of neutrons per pulse in the measurement of the electrical charge at the anode of a photomultiplier, initiated by recoil protons in a scintillation counter. Two scintillation detectors using PPS-1 type polystyrene were built to meter the neutron yield of the existing low intensity one-shot plasma sources. The flux measurement precision in this case does not exceed 30 to 50%. Figures 5, references 10: 6 Russian, 4 Western.  
[115-8225]

## NEUTRON MEASUREMENTS IN EXPERIMENTS WITH HIGH CURRENT ELECTRON BEAMS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA AKADEMII  
NAUK SSSR: NEYTRONNO-FIZICHESKIYE ISSLEDOVANIYA in Russian Vol 127, 1980 pp 84-88

VOLOBUYEV, I. V., GRANATKIN, B. V., deceased, IVANOV, V. N., ISAKOV, A. I.,  
KOLOMENSKIY, A. A., LIKHACHEV, V. M., SINIL'SHCHIKOVA, I. V. and SMIT, O. A.

[Abstract] The technique of neutron producing threshold nuclear reactions can be used to study the interaction of an electron beam with matter. This paper describes the application of the method to the study of the generation of fast hydrogen and deuterium ions in the "Impul's" installation of the Physics Institute of the USSR Academy of Sciences. The neutrons are moderated down to thermal energies and recorded by the radioactivity they produce; the technique is effective in the presence of an intense electron beam and a strong x-ray background. Either silver or indium is used for the detectors and the relevant reactions are given. The experimental set-up is drawn; the specifications are: electron energy of 0.3 to 1 MeV, current of 10 to 30 kA and current pulse duration of 50 ns. The  $C_6^{12}(p, n)N_7^{13}$  and  $Be_4^9(p, n)B_5^9$  threshold nuclear reactions were used to study the acceleration of the ions. The neutron yield is plotted as a function of the gas pressure; the maximum yield was obtained at 0.12 torr when the drift chamber was filled with deuterium and 0.2 torr when filled with hydrogen. The deuteron pulse duration was 10 to 15 ns and that of the hydrogen ions was 5 to 7 ns; the total number of particles in a pulse was  $10^{12}$  ions. The neutron yield in the  $C_6^{12}(p, n)N_7^{13}$  reaction is plotted as a function of the position of the graphite target (in a Faraday cylinder) in the drift chamber. The maximum yield of about  $10^8$  n/pulse was observed at a distance of about 50 cm from the anode foil and was absent at distances of less than 15 cm. The measurements indicated that ions are accelerated over a segment of only about 30 cm. The slight change in the neutron yield rate with distance attests to the small angular divergence of the accelerated particles. The accelerated ion energy was determined by three independent methods (transit time, foil absorption and magnetic spectrography). This energy depends on the operational stability of the accelerator as well as the experimental conditions and ranges from 1 to 4 MeV. Figures 3, references 16: 6 Russian, 10 Western.  
[115-8225]

UDC 621.378.9

## POLYMER LASER TARGETS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA AKADEMII  
NAUK SSSR: NEYTRONNO-FIZICHESKIYE ISSLEDOVANIYA in Russian Vol 127, 1980 pp 72-83

BUSHUYEV, V. S., DOROGOTOVTSEV, V. M., ISAKOV, A. I., KOBETS, N. S., KOZYREVA, N.M.,  
KORSHAK, V. V., KRUPININA, L. A., MERKUL'YEV, Yu. A. and NIKITENKO, A. I.

[Abstract] The following sequence of operations is used to fabricate polymer thermonuclear laser targets: 1. preparation of the initial materials by



suspension polymerization; 2. drying of the granules, sorted according to size; 3. introduction of the foaming agent; 4. foaming in free fall in a furnace; 5. preliminary mechanical sorting; 6. optical quality control and selection, measurement of target parameters; 7. mounting of the target on a support. A manufacturing technique is detailed which produced polystyrene microspheres, 10 to 30% of which meet the requirements for laser targets. A unique feature of the proposed technology is the use of an electrostatic disperser to break the initial liquids up into droplets of uniform size. The vertical tubular electric furnace used to convert the raw granules to a hollow spherical shell is thoroughly described and graphs are plotted showing the influence of the external pressure on shell size, the shell size as a function of the amount of foaming agent and the diameter of the hollow spherical shell as a function of temperature. The final stage of target production from the shell, which involves the removal of the shell from solid particles and pieces of foam, as well as the optical quality control, selection, measurement and filling with fuel, and where necessary, mounting on a support, is also detailed. The characteristic time for hydrogen filling or leakage from the polymer shell is plotted as a function of the radius for both polymer and glass shells. In the final operation of preparing the target for experimental work, it is held on a polymer and glued to a 3 to 5 micrometer glass capillary. While considerable success has been achieved in the authors' laboratory (not specified), work is still underway on producing shells from a polymer solution and developing techniques for the dispersion of the raw materials into particles of equal size; promising here is the use of electrostatic and ultrasonic methods. Figures 10, references 16: 8 Russian, 8 Western. [115-8225]

UDC 621.378.9

#### PROBLEMS RELATED TO THERMONUCLEAR LASER TARGETS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA AKADEMII NAUK SSSR: NEYTRONNO-FIZICHESKIYE ISSLEDOVANIYA in Russian Vol 127, 1980 pp 62-71

ISAKOV, A. I., MERKULOV, Yu. A. and NIKITENKO, A. I.

[Abstract] Laser induced thermonuclear fusion requires target microspheres manufactured to extremely close tolerances. The major goal of target technology is the development of fabrication techniques which optimize the plasma parameters for a specific class of lasers. This paper discusses the state of the art in target manufacture and analyzes the problems related to the physics of the processes in such targets as well as the research trends in this field for the immediate future. A brief discussion of the preparation of the raw materials and the fabrication of the microsphere shells is followed by an examination of the preliminary selection and optical quality control of the targets in light of U.S. experience at the Livermore Laboratory. A brief review of the incorporation of the thermonuclear fuel in the target precedes an extensive treatment of targets for the diagnosis of the processes of plasma heating and compression. Nuclear reactions which produce neutrons or charged particles in a laser plasma are summarized in tabular form; it is noted that Soviet technology can make microspheres

capable of introducing of up to 30 - 50% of Li, Be, B and other oxides into the target wall, where the targets are 500 to 800 micrometers in diameter with a wall thickness of 10 to 20 micrometers. The problem of designing targets for thermonuclear microexplosions is particularly difficult, though in the next 3 to 5 years neutron sources will appear which are capable of producing a large number of neutrons ( $10^{14}$  per flash) within  $10^{-10}$  second in a volume on the order of  $10^{-8}$  cm<sup>3</sup>. This general survey paper deals primarily with U.S. experience and promising trends, providing no data on experimental or production technologies. References 47: 15 Russian, 32 Western.  
[115-8225]

UDC 621.378.9:533.9.01

# PLASMA DYNAMICS OF 'PLASMA FOCUS' AND STUDY OF HIGH POWER LASER RADIATION IMPACT ON IT

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA AKADEMII NAUK SSSR: NEYTRONNO-FIZICHESKIYE ISSLEDOVANIYA in Russian Vol 127, 1980 pp 32-61

GRIKOV, V. A., DUBROVSKIY, A. V., ISAKOV, A. I., KALACHEV, N. V., KOZLOVA, T. A., KORZHAVIN, V. M. and NIKULIN, V. Ya.

[Abstract] The FLORA experimental facility was designed and constructed at the Physics Institute of the USSR Academy of Sciences to study plasma heating and develop a high power neutron source for both neutron physics and the study of engineering problems of controlled thermonuclear fusion. FLORA consists of a 20-channel neodymium laser and a plasma focus. The laser parameters: 1 kJ with a pulse duration of 2 ns and a contrast of no worse than  $10^5$  at a divergence of about  $5 \cdot 10^{-4}$ . The Filippov type plasma focus uses energy stored in a capacitor bank of about 50 kJ at voltage of 20 - 30 kV and maximum current of 1 MA. The neutron yield (x-ray mode) is about  $5 \cdot 10^9$  n/pulse. The installation provides the following observational capabilities: five-frame simultaneous interferometric and shadow photography, hard x-ray spectrometry using high speed photomultipliers, infrared spectrometry of the plasma as well as a camera obscura operating in the maximum absorption band. All of these instrumentation techniques and hardware are discussed in considerable detail. The dynamic behavior of the focus is analyzed in the following modes: a pinch with a single compression, a pinch with a second compression, an x-ray mode without pinching, the focus with 0.7 torr H<sub>2</sub> and traces of N<sub>2</sub> in the chamber as well as the case of a copper plasma corona. The exhaustive treatment of the plasma focus covers: estimates of the rate of convergence of the current shell ( $2.3 \cdot 10^7$  cm/s) from R-t diagrams, rough estimates of the ion temperature at the initial compression (1 keV), discusses possible channels for plasma energy losses, the separation of the shock wave from the current shell, MHD instability of the focus, plasma capture by a magnetic field and the IR spectrum of the plasma. Multiple frame interferometric and shadow photographs as well as hard x-ray and IR spectrometry were used to study the neutron emission and x-ray generation modes of the focus, with a qualitative and quantitative discussion of: the time behavior and evolution of

the hard x-radiation; the absolute hard x-radiation yield of the plasma focus; the focusing of the relativistic electron flux as well as the processes related to the interaction of relativistic electrons with the plasma focus anode. The change in plasma focus behavior with the combined action of an electron beam and laser radiation with energy of about 500 J and pulse duration of 2 ns is described, where the laser is focused on the surface of the copper anode. The experimental configuration is shown and the discussion concentrates on the behavior of the pinch and the anode plasma. A reduction in the minimum pinch radius at the moment of maximum compression is noted as well as the generation of a relativistic electron flow and a copper plasma jet. The overall detailed treatment of the FLORA facility is complemented with photographs illustrating all of the techniques employed. Figures 35, references 53: 33 Russian, 20 Western.  
[115-8225]

UDC 539.12.17

#### CALCULATING FIELD OF RADIATION OF EXTENDED SOURCE

Tomsk IZVESTIYA VYSSHNIK UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 24, No 4, Apr 81 (manuscript received 5 Feb 80) pp 40-43

KOL'CHUZHNIKIN, A. M., Scientific Research Institute of Nuclear Physics at Tomsk Polytechnical Institute imeni S. M. Kirov

[Abstract] The author considers the problem of the readings of a detector with sensitivity function  $D(r, p)$  ( $p = \Omega, E$  are the direction of motion and the energy of a particle) in the radiation field produced by a source with probability density function  $S(r, p)$ . If this density varies slowly at distances of the order of the mean free path of the particles, the solution can be written in the form of a series with terms that are expressed via the Legendre transformants of the probability density function of the source and the equilibrium Green's function. Formulas are derived that can be used to calculate the field of secondary electrons in a substance irradiated with gamma quanta, in solving some transport problems by the method of perturbations, and in using a Monte Carlo technique to calculate the low-energy component of the trajectories of particles in matter. References 5: 4 Russian, 1 Western.  
[211-6610]

#### EXPERIMENTAL STUDIES OF ACCELERATION OF THIN FOILS EXPOSED TO INTENSE LASER PULSES

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 81, No 1(7), Jul 81 (manuscript received 30 Dec 80) pp 170-178

BONDARENKO, Yu. A., BURDONSKIY, I. N., GAVRILOV, V. V., ZHUZHUKAL, V. V., KOVAL'SKIY, N. G., KOLOMIYSKIY, A. N., KONDRASHOV, V. N., MKHITAR'YAN, L. S., PERGAMENT, M. I. and YAROSLAVSKIY, A. I.

[Abstract] In the interest of clarifying the problem of the minimum pulse energy that is required in laser-driven fusion to initiate a self-sustained thermonuclear reaction, experiments are done on the acceleration of foils, measurement of

hydrodynamic efficiencies and investigation of mechanisms of heat conduction in a laser plasma. The neodymium laser used in the experiments produced radiation with intensity of  $(2-3) \cdot 10^{14} \text{ W/cm}^2$ . The laser pulse energy at a duration of 3.0 ns ranged from 100 to 300 J. The targets were thin metallic foils of various materials, organic films, and thin two-layer foils. Interferometric and shadow methods were used for studying plasma motion on both sides of the target. Instrumentation also included an 8-channel x-ray spectrometer and a magnetic analyzer for studying the spectrum of fast electrons. The energy and shape of the incident laser pulse were determined as well as the distribution of radiation intensity in the far zone and the energy contrast of the laser system. The results agree with two-dimensional hydrodynamic calculations. The maximum velocity of motion of material on the back side of the foil was registered for aluminum 6  $\mu\text{m}$  thick, and was  $5 \cdot 10^6 \text{ cm/s}$  at laser pulse energy of 100 J. Calculated hydrodynamic efficiency in this case was about 5%. No limitations on heat fluxes as compared with the predictions of the classical theory were found in the investigated intensity range. It was found that x-ray emission of the plasma corona has a considerable effect on the foil component that is accelerated. X-ray analysis shows that no more than 0.01% of the total number of electrons in the plasma corona can be considered "hot" (effective temperature of about 5 keV) at this light flux density. Figures 6, references 6: 5 Russian, 1 Western.  
[253-6610]

UDC 533.9:533.952.16

#### CAPABILITIES OF EXPLOSIVE MHD GENERATOR AS ENERGY SOURCE FOR PLASMA FOCUS

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСКОY FIZIKI in Russian  
No 3(127), May-Jun 81 (manuscript received 7 Apr 80) pp 81-86

BURENIN, Yu. A. and SHVETSOV, G. A., Novosibirsk

[Abstract] The plasma focus is currently one of the most intense sources of neutron and x-ray emission. In this paper an analysis is made of the capabilities of an explosively driven magnetic field compression generator with plasma focus as an energy source. Numerical methods are used to study the motion of the current shell in a non-cylindrical Z-pinch with an explosive MHD generator used as the source of energy, and it is shown that under matched conditions the energy transfer from the explosively driven generator to the plasma of the current shell may be considerable. Figures 3, references 9: 5 Russian, 4 Western.  
[237-6610]



# **NN-OSCILLATIONS: POSSIBILITY OF OBSERVATION BY USING ULTRACOLD NEUTRONS**

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 31, No 1, 5 Jul 81 (manuscript received 1 Jun 81) pp 49-53

KAZARNOVSKIY, M. V., KUZ'MIN, V. A. and SHAPOSHNIKOV, M. Ye., Institute of  
Nuclear Research, USSR Academy of Sciences

[Abstract] Recently there has been a considerable upsurge of interest in effects due to nonconservation of baryon number, and particularly in  $\bar{N}N$ -oscillations. In connection with the results of certain theoretical estimates of the expected intensity of neutron-antineutron transitions in an experiment with ultracold neutrons with simplified assumptions regarding interaction of the neutron-antineutron superposition with the wall of the trap, the authors study the behavior of such a superposition and find conditions under which an experiment with ultracold neutrons may be expected to be informative. References 12: 5 Russian, 7 Western.  
[239-6610]

UDC 533.951.8

# **INTERNAL KINK MODES IN TOKAMAK OF NONCIRCULAR CROSS SECTION WITH HIGH PLASMA PRESSURE**

Moscow FIZIKA PLAZMY in Russian Vol 7, No 3, May-Jun 81 (manuscript received 28 Jan 80 after revision 1 Sep 80) pp 678-686

KRYMSKIY, A. M., Rostov State University

[Abstract] An investigation is made of the influence that slight ellipticity and triangularity of the cross section of a tokamak shell have on the stability of large-scale internal kink modes  $m \geq 1$  as a consequence of toroidality and finiteness of pressure of the plasma. It is assumed that the longitudinal current density gradient is small, and plasma pressure is not too high ( $\beta_J \alpha_*/R < 1$ ,  $\beta_J \gg 1$ ,  $\beta_J = p(0)/B_\theta(\alpha_*)$ ,  $\alpha_*$  is the coordinate of the surface of the plasma column,  $R$  is the major radius of the tokamak,  $p$  is plasma pressure,  $B_\theta$  is the poloidal magnetic field). An equation of small oscillations is derived that describes the behavior of internal kink modes  $m \geq 1$  in a tokamak of noncircular cross section at high plasma pressure. An examination is made of the influence that small ellipticity and triangularity have on mode  $m = n = 1$ . A method is given for accounting for the influence of noncircularity that is due to toroidality of the magnetic field, and an expression is derived for the "quasicylindrical" contribution of ellipticity. References 14: 10 Russian, 4 Western.  
[227-6610]

## SPACE-TIME FOCUSING OF CHARGED PARTICLES IN FIELDS WITH ROTATIONAL SYMMETRY

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 5 May 80) pp 1137-1145

DAUMENOV, T. D., SAPARGALIYEV, A. A., SEKUNOVA, L. M. and YAKUSHEV, Ye. M.,  
Institute of Nuclear Physics, KaSSR Academy of Sciences, Alma-Ata

[Abstract] A general theoretical study is done on the space-time focusing of bunches of charged particles by electric fields. The analysis is based on consideration of the motion of a particle with charge  $e$  and mass  $m$  in an electrostatic field characterized by a given scalar potential with rotational symmetry relative to the principal optical axis of the optoelectronic system. The equations of motion of the particles are solved by a method of successive approximations. It is shown that space-time focusing of thin bursts of charged particles may be realized if the field with respect to the particles is an electronic mirror. The spatial and temporal characteristics are studied in the first approximation, and aberrations of the second order of smallness are found. The proposed method of calculating the space-time focusing properties of optoelectronic and ion-optical systems are applicable to fields of any symmetry. References 6 Russian.  
[221-6610]

UDC 533.9:621.039.61

## INTEGRAL METHOD OF CALCULATING PLASMA EQUILIBRIUM IN A TOKAMAK

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 3 May 80) pp 1289-1290

FLATOV, O. G., Scientific Research Institute of Electrophysical Apparatus imeni  
D. V. Yefremov, Leningrad

[Abstract] The integral method of solving the problem of plasma equilibrium in a tokamak proposed by Zakharov provides an effective numerical procedure for calculating equilibrium with containment by a jacket, external fields produced by discrete currents, and also a combination of these methods. In calculating equilibrium with containment by a jacket, Zakharov constructed the integral equation by using an analog of the Green's function of the corresponding problem. The author now suggests a different approach for this same case, based on an analog of classical potential theory. It is shown that for known current distribution in the plasma the poloidal magnetic flux can be represented as a potential of area and a potential of the simple layer distributed on the boundary of the plasma. References 6: 4 Russian, 2 Western.  
[221-6610]

## HOLOGRAPHIC RECORDING ON FILMS OF COPPER PHTHALOCYANINE

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 26, No 6, Jun 81  
(manuscript received 10 Jun 80, in final version 28 Jun 80)

SAVCHUK, A. V., SAL'KOVA, Ye. N., Institute of Physics, UkrSSR Academy of Sciences, Kiev, HAMANN, K. and STARKE, M., Technical Institute, Karl-Marx, Stadt (GDR)

[Abstract] Recording of stationary relief holograms on CuPc (copper phthalocyanine) films was studied to determine the suitability of such films and the necessary process requirements. High-purity CuPc can be obtained by sublimation during nondestructive heating up to 590°C in an atmosphere of an inert gas under pressures up to 760 mm Hg. Thin (200-300 nm thick) films of this material were deposited on glass substrates at 30°C by the vacuum evaporation process and relief holograms then recorded on them with a light beam from a ruby laser ( $\lambda = 0.69 \mu\text{m}$ ) operating in the free-emission mode (pulse duration 300  $\mu\text{s}$ ) or in the giant-pulse mode (pulse duration 10-30 ns) with a 50% alcohol solution of kryptocyanine as the modulator. The 2-beam method (ratio of intensities 1:4) was used for recording and an He-Ne laser beam ( $\lambda = 0.63 \mu\text{m}$ ) was used for reconstruction. Recording in the giant-pulse mode was found to be preferable, a larger area being covered in the same exposure time without partial erasure. Also the diffraction efficiency was found to be higher than in the free-emission mode, up to 10% and not decreasing so much with higher space frequencies. A recording can be made within  $10^{-6}$ - $10^{-8}$  s and does not require additional processing of the holograms. Figures 2, references 7: 5 Russian, 2 Western. [243-2415]

## DEPENDENCE OF BRIGHTNESS OF HOLOGRAPHIC IMAGE OF NONSTEADY SCATTERING LAYER ON SCATTERING ANGLE

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 26, No 6, Jun 81  
(manuscript received 30 Jun 80, in final version 4 Aug 80) pp 1011-1014

ANGEL'SKIY, O. V., Chernovtsy State University

[Abstract] In formation of holographic images the coherence of light is degraded due to scattering by moving particles. Here the mechanism of this degrading is examined by considering a stationary object and a nonsteady layer of a scattering medium which consists of Brownian particles, both treated as arrays of optical relays. The interaction of coherent light and this array of moving particles is analyzed in the single-scatterer approximation, disregarding the form of the relay response, i.e., its dependence on the size of particles. The interference pattern established by the object field and the reference field yields a relation which describes the dependence of the image brightness on the scattering angle. The results have been verified by holographic experiments with a test tube containing a turbid fluid (milk suspension in distilled water) and a sharply collimated He-Ne illuminating laser beam, the recording reference laser beam having a plane wave front. With the scattering angle varied over the  $4-28^\circ$  range under otherwise favorable and unchanging conditions, the image brightness was found as expected to increase as the scattering angle decreased, at a rate which decreased fast with increasing angle after a shorter exposure ( $t = 3$  s) and much slower after a longer exposure ( $t = 6$  s). The author thanks V.K. Polyanskiy for discussing the results. Figures 2, references 6: 4 Russian, 2 Western. [243-2415]

UDC 621.371.24:535.2

## AVERAGE INTENSITY OF LIGHT BEAM IN WEAKLY NONLINEAR TURBULENT ATMOSPHERE

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 24, No 4, Apr 81 (manuscript received 27 Feb 80) pp 37-40

MIRONOV, V. L., NOSOV, V. V. and CHEN, B. N., Institute of Optics of the Atmosphere, Siberian Department, USSR Academy of Sciences

[Abstract] An earlier paper by V. V. Vorob'yev deals with the average intensity of a light beam propagating in a turbulent medium with cubic nonlinearity, which is accounted for by the method of perturbations, the medium itself being taken as made up of inhomogeneities having the shape of random wedges with the overall effect of rotating the beam as a whole. In this approximation, the attenuation of average intensity is due only to departures of the beam from its own axis. In this paper the authors consider the problem of beam intensity in a real atmosphere where fluctuations of permittivity conform to the Kolmogorov-Obukhov



"2/3 law." It is shown that an increase in turbulence intensity causes abatement of the nonlinear component of average beam intensity. However, in the real atmosphere with strong turbulent beam broadening, the average intensity component due to nonlinearity is different from that found by Vorob'yev [V. V. Vorob'yev, IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY USSR: RADIOFIZIKA, Vol 14, No 6, 1971, p 865]. These components are related by a transformation corresponding to a linear medium. References 11: 9 Russian, 2 Western.  
[211-6610]

#### RESONANT EXCITATION AND HYSTERESIS IN QUANTUM ANHARMONIC OSCILLATOR

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 33, No 10, 20 May 81 (manuscript received 26 Mar 81) pp 504-507

ROZANOV, N. N. and SMIRNOV, V. A., State Optics Institute imeni S. I. Vavilov

[Abstract] There has been a recent upsurge of interest in hysteresis effects that accompany the action of optical radiation. The simplest model of an object exposed to such action is the anharmonic oscillator, which is applicable to a wide range of problems. The authors consider hysteresis of solutions of the Schrodinger equation, taking the state of a free harmonic oscillator as the zero approximation. It is shown in application to the problem of resonant excitation of a quantum anharmonic oscillator by an external force that hysteresis is present in the oscillations, a new branch showing up between the "classical" branches in the resonance curve. It is shown that the degree of excitation increases sharply with a reduction in frequency mismatch. These effects can be observed in the infrared spectra of simple molecules such as CO, NO and HCl when they are exposed to tunable-frequency laser emission. Figure 1, references 16: 13 Russian, 3 Western.  
[207-6610]

#### SPIN RAMAN SCATTERING OF LIGHT BY $Ce^{3+}$ IONS IN CERIUM-MAGNESIUM NITRATE CRYSTAL

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 33, No 10, 20 May 81 (manuscript received 10 Apr 81) pp 525-528

AL'TSHULER, S. A., NAZAROV, Yu. G. and KHASANOV, A. Kh., Kazan' State University imeni V. I. Ul'yanov-Lenin

[Abstract] It is known that inelastic scattering of light due to spin-phonon interaction may be observed in magnetic materials. Until now, spin Raman scattering of light has been studied only in magnetically ordered materials and semiconductors. In this paper the authors report spin Raman scattering of light by  $Ce^{3+}$  ions in a paramagnetic crystal of  $Ce_2Mg_3(NO_3)_{12} \cdot 24H_2O$  (CeMgN). Experiments were done with  $90^\circ$  scattering of light in CeMgN at 1.7 K in a constant magnetic field. The experimental setup is shown in the diagram. Single-frequency laser radiation with wavelength of 488 nm and power of 0.3 W scattered by the crystal

was analyzed by a Fabry-Perot interferometer. An interference filter with pass-band of 0.1 nm reflected the spectrum of the interfering vibrational Raman scattering. The time constant of the recording system was 4 s. Polarized scattering spectra were obtained for four orientations of the specimen relative to the vectors of the incident and scattered light, the direction of the external magnetic field being always perpendicular to the optical axis of the crystal. In the absence of a magnetic field, the spectrograms showed only the components of Mandelstam-Brillouin scattering. In a non-zero field, doublet lines were observed with shifts relative to the frequency of laser emission corresponding to the frequency of transitions between Zeeman levels of the effective spin of  $Ce^{3+}$  ions in the ground electron state. The shape of the observed spin doublet lines was determined mainly by the frequency-response function of the Fabry-Perot interferometer. The spin scattering effect is weak compared with phonon scattering of light. The low intensity is attributed to the fact that the levels of the 5d configuration are far above the virtual state. Figures 3, references 5: 3 Russian, 2 Western.

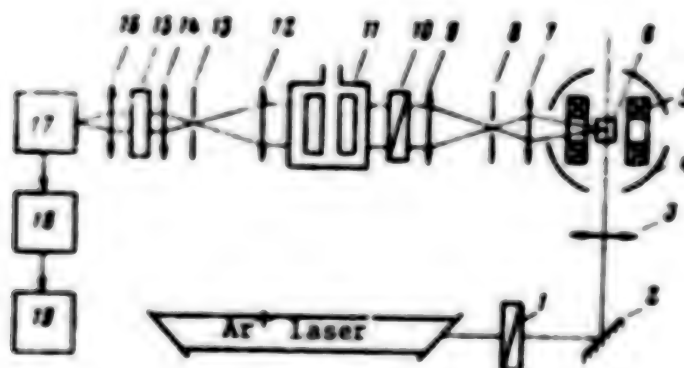


Figure 1. 1--rotator of the polarization plane, 2--mirror, 3, 7, 9, 12, 14, 16--objective lenses, 4--optical cryostat, 5--superconductive Helmholtz coils, 6--specimen, 8, 13--diaphragms, 10--polarizer, 11--Fabry-Perot interferometer enclosed in a pressure chamber, 15--interference filter, 17--FEU-79 photomultiplier, 18--electrometric amplifier, 19--chart recorder

[207-6610]

**TRANSVERSELY PROPAGATING LUMINOUS DISCHARGES AND FLARES FROM MOVING LASER BEAMS--  
NEW CLASS OF OPTICOGASDYNAMIC PHENOMENA**

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 33, No 10, 20 May 81 (manuscript received 10 Apr 81) pp 528-533

ASKAR'YAN, G. A. and MANZON, B. M., Physics Institute imeni P. N. Lebedev,  
USSR Academy of Sciences

[Abstract] Luminous discharges in gases usually propagate counter to the beam that produces them. Another effect that has been observed is intrusion of a beam into a gas medium, heating and dispersing the medium along its path--luminous discharge along the beam. This paper investigates a new class of radiative-gasdynamics effects--transverse propagation of luminous discharges with a moving beam. A beam moving across the axis was produced by using a laser working in the generation wave mode: in the optical cavity at a small angle to the mirrors was a metallized Mylar film covering the mirror of the cavity and upsetting the Q. Localized transillumination of the metallization by an auxiliary laser at the instant of maximum inversion produces a giant lasing pulse at the point of initiation. Vaporization of the metal coating by radiation expanding due to angular divergence produced the generation wave and set up a moving beam. The output beam from the laser produced a discharge in air as it moved, initiated either by gas breakdown at the focus or by a metal surface. The surface was sequentially placed at different distances from the focus to observe transversely propagating luminous discharges at different velocities of beam motion and different intensities corresponding to different rates of luminous detonation. Plasma surfaces of different configurations were produced in the experiments. The conditions for maintaining and interrupting discharge propagation are given. It is shown that discharge propagation can be controlled by beam motion. Figures 3, references 11 Russian.  
[207-6610]

**MANY-PHOTON RESONANT PARAMETRIC UP-CONVERSION OF SIGNAL FREQUENCY IN  
NONMONOCHROMATIC PUMPING FIELD**

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 33, No 10, 20 May 81 (manuscript received 15 Apr 81) pp 542-545

ISKANDEROV, N. A., KUDRYASHOV, V. A., MATVEYEV, I. N. and USTINOV, N. D.

[Abstract] Investigation of the behavior of higher optical nonlinearities under resonance conditions is of interest in connection with a wide range of applied and spectroscopic problems. In this paper, a model of a two-level medium is used as a basis for theoretical analysis of the process of up-conversion of signal frequency on nonlinear susceptibility of arbitrary order in many-photon resonance of a given nonmonochromatic pumping field with consideration of the motion of populations, unsteady response of the medium, Stark shifting of levels and the width of the frequency spectrum of the field. It is shown that parametric

up-conversion under the given conditions with excitation of many-photon resonance should reduce or eliminate dynamic gain in the average efficiency of conversion in a field of picosecond and nanosecond pumping pulses because of light-induced relaxation. On the other hand, when a steady state has been established the average conversion efficiency may be considerably higher than in a monochromatic field due to increased saturating intensity in the nonmonochromatic pumping field.

Figure 1, references 7 Russian.

[207-6610]

UDC 551.521.3:551.510.42

#### DETERMINING DISTRIBUTION OF WATER VAPOR CONCENTRATION FROM OUTER-SPACE MEASUREMENTS OF VERTICAL BRIGHTNESS PROFILES OF THE ATMOSPHERE

Tallinn IZVESTIYA AKADEMII NAUK ESTONSKOY SSR: FIZIKA, MATEMATIKA in Russian Vol 30, No 2, Apr-Jun 81 (manuscript received 27 Nov 80) pp 140-145

KNYAZIKHIN, Yu., Institute of Cybernetics, ESSR Academy of Sciences

[Abstract] Experiments done in 1975 on the Salyut-4 orbital laboratory provided vertical brightness profiles of the atmosphere in the near infrared. Methods of solving the inverse problem of determining vertical profiles of the coefficient of aerosolic scattering from intensities of solar radiation obtained on board this space station were later developed by the Institute of Astrophysics and Physics of the Atmosphere of the ESSR Academy of Sciences, and by the Computing Center of the Siberian Department of the USSR Academy of Sciences. In this paper, the author continues this study, solving the inverse problem of atmospheric optics: determining the distribution of water vapor concentration. The solution is based on the Newton-Kantorovich and Monte Carlo method. It is shown that for models of pure scattering with small zenith angles of the sun, the attenuation of rays from the sun to the impact point can be disregarded in calculations of single scattering, which facilitates compilation of algorithms for solving inverse problems on determination of coefficients of aerosolic scattering for a purely scattering atmosphere. However, attenuation of radiation on the path from the sun to the impact point has a considerable effect on the intensity of single scattering for a model with absorbing elements. Figure 1, references 10: 9 Russian, 1 Western. [254-6610]

#### AMPLIFICATION OF REFLECTED LIGHT IN DISPERSING LASER PLASMA

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 81, No 1(7), Jul 81 (manuscript received 7 Aug 80) pp 146-150

GORBUNOV, L. M., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] When laser emission acts on a target, the light waves that are incident and reflected from the dense plasma form a standing electromagnetic wave in the dispersing rarefied plasma corona. The resultant pondermotive forces



cause density perturbations that are especially appreciable in the resonant region where the velocity of plasma dispersal is of the order of the speed of sound, and the Mach number is close to unity. Scattering by these perturbations increases light reflection. Previous research on this effect has been based on simplified models of the plasma corona, and has not explained the main principles governing the phenomenon. In this paper the amplification of reflected light is analyzed in a more realistic model with consideration of the spatial behavior of density perturbations and the intensities of the incident and reflected light. The reflectivity is determined. It is shown that the intensity of emission necessary for reaching dense plasma layers and thus increasing efficiency of amplification of the reflected light is a function of the scale of variation in flow velocity of the plasma, and is independent of the intensity of the incident radiation as long as the latter exceeds a certain threshold value. Figures 2, references 11: 3 Russian, 8 Western.  
[253-6610]

UDC 533.915

#### NITROGEN HEATING IN SELF-MAINTAINED GLOW DISCHARGE

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСКОY FIZIKI in Russian  
No 3(127), May-Jun 81 (manuscript received 10 Apr 80) pp 10-13

AKISHEV, Yu. S., ZAKHARCHENKO, A. I., GORODNICHEVA, I. I., PONOMARENKO, V. V.  
and USHAKOV, A. N., Moscow

[Abstract] Interferometric measurements are used to determine the fraction of Joule power expended on rapid heating of nitrogen containing less than 0.01% impurities in the range of  $E/N = (4-8) \cdot 10^{-16} \text{ V} \cdot \text{cm}^2$  at pressures of 20-80 mm Hg ( $E$  is electric field strength in the glow discharge,  $N$  is the density of the gas). The experimental setup included facilities for producing a quasi-steady discharge with duration of about 0.6 ms and current density of 10-100 mA/cm<sup>2</sup>, and a Mach-Zehnder interferometer with pulsed He-Ne laser and a system for recording interference patterns based on a streak camera. The design of the facility, the duration of the quasi-steady discharge and the range of specific Joule powers gave quasi-equilibrium conditions of gas heating at which the pressure in the discharge region remained constant and equal to the initial pressure in the discharge chamber. The influence of slow heating could be disregarded since the times of V-T and V-V-T relaxation for nitrogen under the experimental conditions were much longer than the discharge pulse duration. It is shown that the fraction of Joule power that determines rapid heating can be found if heating of the gas is known in a given time interval at a predetermined time-independent Joule power of electrons. This heating was found from interferometric measurements defining the change of gas density in the gas using the condition of constant pressure in the discharge zone. The interference patterns of the discharge gap were computer-processed. It was found that the fraction of Joule power that determines rapid heating under the experimental conditions ranges from 3.5 to 0.5% in the range of investigated values of  $E/N$ . Figure 1, references 10: 7 Russian, 3 Western.  
[237-6610]

## STIMULATED SCATTERING OF PARTLY COHERENT OPTICAL EMISSION

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 45,  
No 6, Jun 81 pp 945-957

BETIN, A. A., MANISHIN, V. G. and PASMANIK, G. A., Institute of Applied Physics,  
USSR Academy of Sciences

[Paper presented at the Tenth All-Union Conference on Coherent and Nonlinear  
Optics, Kiev, 14-17 October, 1980]

[Abstract] Previous research on the problem of stimulated scattering of light fields has dealt mainly with spatially coherent radiation. Work on certain details of stimulated scattering of partly coherent light shows appreciable dependence of scattering efficiency on pumping coherence. However, such studies have assumed negligible mismatch of group velocities and difference between wave vectors on the interacting waves. In this paper, a theoretical analysis is made of new effects typical of nonlinear wave processes in a field of partly coherent optical emission in Raman scattering. A dynamic approach is used that is based on expanding the fields of the light waves with respect to a minimum set of orthogonal space-time modes determined from boundary conditions, and accounting for the interaction of sample combinations of these modes. As a result, conditions are found under which stimulated scattering occurs mainly only for certain components of the partly coherent pumping radiation, while scattering of other components is inhibited. This indicates new possibilities for using stimulated scattering to process optical information, including for isolating useful signals against a noisy background. Figure 1, references 21 Russian.  
[245-6610]

UDC 681.787:778.38

## CALCULATING ADMISSIBLE ERRORS IN HOLOGRAPHIC INTERFEROMETERS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 5, May 81  
(manuscript received 12 Jul 80) pp 1-2

BEKETOVA, A. K. and SILINA, T. V.

[Abstract] The authors consider the feasibility of determining quality requirements of the optical components and systems of holographic interferometers with consideration of the influence of transparent inhomogeneities of the optical system on distortion of interference bands. It is shown that the method of holographic interferometry does not permit compensation of aberrations due to a change in direction of light beams passing through an inhomogeneity. Uncompensated errors of holographic interferometers IZK-462 and IZK-463 were calculated and compared with analogous errors for the IAB-451 shadow instrument and the IZK-454 Mach-Zehnder interferometer used as holographic interferometers. The calculations were done for several discrete values of the aperture angle in a range of  $10^{-5}$ - $18 \cdot 10^{-3}$  radian.

It was found that errors due to wave aberrations of the systems within the limits of the acting beam are negligible when studying inhomogeneities with angular deflections of light beams of  $5 \cdot 10^{-4}$  radian or less. Although the error may increase considerably in the case of "coarse" inclusions, the relative error may still remain within admissible limits. Figures 2, references 3 Russian. [240-6610]

UDC 535.317.1

**FEASIBILITY OF RECONSTRUCTING IMAGE OF OBJECT UNDISTORTED BY ATMOSPHERE FROM  
N SPECKLE INTERFERENCE PATTERNS**

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 50, No 6, Jun 81  
(manuscript received 17 Apr 80) pp 1191-1192

BAKUT, P. A., SVIRIDOV, K. N. and USTINOV, N. D.

[Abstract] Spectrally filtered short-exposure images of astronomical objects observed through a turbulent atmosphere show speckle patterns. This effect can be explained by the interference of light waves from the object diffracted by a phase screen created by the turbulences of the atmosphere in front of the telescope aperture. Labeyrie first suggested a method in 1970 for processing speckle interference patterns to determine the geometric characteristics of astronomical objects. This technique was based on averaging the amplitudes of spatial spectra of  $N$  independent speckle patterns, subsequent recording of the amplitude of the spatial spectrum of the object, and the use of inverse Fourier transformation to reconstruct the autocorrelation of the image of the object undistorted by the atmosphere. This method is not suitable for objects of geometric shape other than centrally symmetric, and thus cannot be applied to such objects as nebulae and globular clusters. In this paper the authors discuss a simple modification of the method based on obtaining the phase of the spatial spectrum of the object by averaging the phases of the spatial spectra of speckle interference patterns. It is demonstrated that this averaging can effectively single out the phase of the spatial spectrum of the object, which is then combined with the amplitude obtained by Labeyrie's technique with subsequent inverse Fourier transformation to reconstruct the image of objects of any geometric shape without atmospheric distortion. References 6: 4 Russian, 2 Western. [234-6610]

## INFLUENCE OF AUGER PROCESSES ON RECOMBINATION OF BOUND EXCITONS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 6, Jun 81

(manuscript received 30 Jun 80) pp 1088-1093

KARAS', V. I. and LOMAKO, V. M.

[Abstract] An increase in carrier concentration due either to doping or to an increase in the level of excitation increases the probability of Auger recombination. With increasing width of the forbidden band, the probability of interband Auger recombination decreases because of a reduction in the number of hot carriers. However, Auger capture of one of the carriers by an impurity center may make a certain contribution to recombination. For example, the influence of Auger collisions has been invoked to explain the experimentally observed behavior of red luminescence relaxation time in gallium phosphide doped with zinc and oxygen. In this paper an analysis is made of the influence that Auger collisions of two particles with capture of either or both by a center have on recombination of bound excitons. It is found that the influence of Auger processes on recombination is complex, and may either reduce or increase the intensity of impurity or exciton luminescence. In most cases, Auger processes are revealed by the behavior of cross sections of capture of both majority and minority carriers by a center. This behavior may depend on degree of doping and on excitation level. Even a reduction in exciton lifetime does not always lead to an increase in the contribution of non-radiative recombination. Carrier recombination with participation of a local center involves at least two sequential processes associated with capture of each of the carriers by a center. If one of these processes is radiative, the other is nearly always non-radiative, and therefore an increase or reduction in luminescence intensity depends on which transition has the greater probability of contribution of an Auger process. If the contribution of the Auger process is more probable in non-radiative capture of one of the carriers by a center, it will lead to an increase in the intensity of the radiative process associated with capture of the other carrier. Figure 1, references 2:

1 Russian, 1 Western.

[229-6610]

UDC 535.853.1

## USING FOURIER SPECTROMETERS TO SOLVE PROBLEMS OF ATMOSPHERIC OPTICS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 6, Jun 81

(manuscript received 16 Oct 78, after revision 16 Jan 81) pp 1104-1107

ILYUKHIN, V. N.

[Abstract] An examination is made of the use of spectral methods in studying energy properties and structure of absorbing components of the atmosphere and underlying surface as a basis for determining vertical temperature profiles and



the vertical profile of moisture content of the atmosphere. It is shown that the temperature profile found from  $\text{CO}_2$  absorption bands can be treated as an approximation to the humidity profile. In choosing instruments for a comprehensive approach to thermal probing of the atmosphere including registration of the spectrum and determination of physical parameters, a useful index is the figure of merit  $W = RM/TB^\alpha$ , where  $M$  is the number of components of the spectrum that can be recorded,  $R$  is resolution,  $T$  is recording time,  $B$  is the brightness of the source and  $\alpha$  is equal to 1 for thermal receivers, and 2 for quantum receivers. It is shown that Fourier spectrometers should have considerable advantages over conventional instruments in threshold sensitivity and signal/noise ratio, and these advantages should increase with saturation of the spectrum. An example is given showing the superiority of Fourier spectroscopy in registration of the  $4.3 \mu\text{m}$  band of carbon dioxide. Figures 2, references 11: 10 Russian, 1 Western. [229-6610]

UDC 535.853

# CORRELATIONAL PROPERTIES OF COHERENT OPTICAL SYSTEMS UNDER LIGHT-SCATTERING CONDITIONS

Minsk IZVESTIYA AKADEMII NAUK BSSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 3, May-Jun 81 (manuscript received 26 Aug 80) pp 65-70

GURSKIY, I. M. and IVANOV, A. P., Institute of Physics, BSSR Academy of Sciences

[Abstract] A theoretical study is done on how the coherence diffusion function  $T(s)$  is affected by the optical characteristics of a scattering medium as applied to communication, position-fixing and ranging systems in the hydrosphere or turbid atmosphere. It is assumed that the intensity distribution in the zone of interaction of two mutually coherent fields is described by the interference relation

$$I_0(x_0) = \bar{I}_0(1 + p_0 \exp 2\pi i \nu_0 x_0),$$

where  $I_0$  is the average intensity,  $p_0$  is initial contrast, and  $\nu_0$  is spatial frequency. The scattering medium changes the intensity distribution to

$$I(x) = \bar{I}_0(1 + T(\nu)T(s) \exp 2\pi i \nu x),$$

where  $T(\nu)$  is the frequency-contrast characteristic of the medium. This expression shows that the interference field has a spatial frequency determined by the angle of convergence of the coherent fields, which means that transmission of a given frequency through the scattering medium is influenced by  $T(\nu)$ . The experiments were done at the Institute of Physics, BSSR Academy of Sciences in a pool measuring  $40 \times 4 \times 3 \text{ m}$  using an LG-106-M1 laser with output power of 1 W on wavelength of  $0.514 \mu\text{m}$ . The interference pattern was produced by a modified Michelson interferometer. The scattering medium was an aqueous solution of milk or a latex emulsion. A wide range of optical characteristics was attained by adding a dye solution to alter the index of absorption  $k$ . Standard equipment was used to measure the index of attenuation  $\xi = \sigma + k$ , where  $\sigma$  is the scattering index. The results show that the contrast of an image transmitted by a coherent optical system through a light-scattering medium is adversely affected both by the way that spatial frequencies are transmitted and by the change in the degree of correlation. Figures 4, references 10 Russian. [222-6610]

## ABERRATIONLESS VARIANTS OF SYMMETRIC MAGNETIC FOCUSING PRISMS WITH HYPERBOLIC FIELD

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 16 May 80) pp 1290-1292

MALOV, A. F. and TRUBACHEYEV, G. M.

[Abstract] The ideal ion-optical scheme of a magnetic spectrometer presupposes high dispersion, high luminosity (strong axial focusing), elimination of spherical and axial image aberrations and a focal line nearly orthogonal to the beam axis. As a rule it is impossible to achieve all these characteristics simultaneously. In particular, calculations show that elimination of aberrations in magnetic spectrometers with a uniform field entails a reduction in dispersion and luminosity with acute angle between the beam axis and the focal line. On the assumption that capabilities of magnetic spectrometers might be extended by going to nonuniform fields, the authors give the results of an investigation of high-dispersions aberrationless versions of magnetic focusing prisms with hyperbolic field. The analysis is limited to the symmetric case. It is shown that spherical and axial image aberrations are eliminated simultaneously when  $\lambda = \sqrt{2}$ . Such prisms should be promising for magnetic spectrometers with high resolution and luminosity. Figures 2, references 4: 3 Russian, 1 Western.  
[221-6610]

# NEW CLASS OF NONLINEAR SURFACE WAVES

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 34, No 2, 20 Jul 81 (manuscript received 19 May 81) pp 64-67

LOMTEV, A. I., Donetsk Physicotechnical Institute, UkSSR Academy of Sciences

[Abstract] A discussion is presented of the possibility of the existence of surface modes at the interface of two nonlinear media occupying half-spaces  $z > 0$  and  $z < 0$  respectively. The discussion is restricted to crystals of uniaxial symmetry in which the tensors of dielectric constants are diagonal but are strongly nonlinear in relation to the amplitude of the electric field. This type of non-linearity is produced by the electro-optical Kerr effect, electrostriction, ionization of a medium by the field of a wave and the like. Maxwell equations are presented for a class of quasi-monochromatic waves. It is assumed that for waves propagating along the x-axis, the physical processes which result in non-linearity occur fairly rapidly during the characteristic change in amplitudes of the field. Exact solutions are found for the Maxwell equations for nonlinear surface waves of P type. A nonlinear dispersion equation is found for surface modes and this equation is transformed into an expression for the refractive index. References 4 Russian.  
[250-8831]

# PHOTOPLASTIC MEMORY IN $A_2B_6$ CRYSTALS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 23, No 6, Jun 81  
(manuscript received 5 May 80, after revision 13 Nov 80) pp 1618-1622

KOROVKIN, Ye. V. and SHIKSAIDOV, M. Sh., Institute of Solid State Physics, USSR Academy of Sciences, Chernogolovka, Noginskiy Rayon, Moscow Oblast

[Abstract] Previous research on aftereffect in  $A_2B_6$  crystals has shown high-temperature photomemory ( $100^\circ\text{C}$ ). Recording is done by exposing a prestrained crystal to light corresponding to the fundamental absorption edge. The memory is retained for several hours at least. Readout is by detection of a characteristic "tooth" when the crystal reaches the stage of plastic flow in mechanical tests. Plastic deformation of the crystal erases the recording. This paper describes the results of experimental studies on the "long-lived" excitations

responsible for the photostorage effect. The experimental technique is described in a previous paper [see G. A. Yermakov, Ye. V. Korovkin, Yu. A. Osip'yan, M. Sh. Shikhsaidov, FIZIKA TVERDOGO TELA, Vol 17, 1975, p 2364]. Analysis of the experimental data shows that such excitations contribute to both the elastic aftereffect and the photoplastic effect. It is concluded that short-lived excitations with lifetime of the order of a minute in the "undistorted" part of the crystal are responsible for the aftereffect, while the photoplastic memory detected in this research is caused by excitations with lifetime of several hours situated in the dislocation region of the crystals. Figures 6, references 4 Russian. [249-6610]

UDC 535.375.55

#### SELF-FOCUSING, RECORDING AND RECONSTRUCTION OF WAVE FRONT OF LIGHT -- NEW EFFECTS IN STIMULATED RAMAN SCATTERING

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 45, No 6, Jun 81 pp 969-975

SOKOLOVSKAYA, A. I.

[Paper presented at the Tenth All-Union Conference on Coherent and Nonlinear Optics, Kiev, 14-17 October, 1980]

[Abstract] New effects are experimentally observed and studied in stimulated Raman scattering, including arisal of a beam of stimulated Raman scattering of high brightness in an optically inhomogeneous medium propagating in the direction counter to the exciting laser radiation, reconstruction of the image of a three-dimensional transparency illuminated by laser emission in beams of Raman and Mandelstam-Brillouin scattering, wave-front reversal in stimulated Raman back-scattering, preferential development of self-focusing in beams of stimulated Raman scattering, and independent focal structure in these beams in substances with a large effective Raman scattering cross section, and Raman self-focusing in condensed media with a small Kerr constant. Raman scattering was stimulated by giant pulses of a ruby laser, and by the second harmonic of a neodymium laser at pulse durations of  $20 \cdot 10^{-9}$  and  $20 \cdot 10^{-11}$  s. The scattering media were organic liquids with large effective Raman scattering cross section, liquid nitrogen and a calcite single crystal. It is shown that the image of a transparency is reconstructed in stimulated Raman scattering so that spatial orientation and magnification conform to the laws of holography. Optimum conditions are determined under which the focal structure in the beam of stimulated Raman scattering does not disrupt the effect of wavefront reconstruction. Figures 7, references 28: 23 Russian, 5 Western. [245-6610]



## DEFLECTING LIGHT BEAMS IN GALLIUM PHOSPHIDE CRYSTAL BY ACOUSTO-OPTICAL METHOD

Tashkent IZVESTIYA AKADEMII NAUK UZSSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK  
in Russian No 2, Mar-Apr 81 (manuscript received 23 Jan 80) pp 64-67

MAMATDZHANOV, F. D., AZAMATOV, Z. T., PARYGIN, V. N., VOLOSHINOV, V. B.  
and TASHPULATOV, Kh. Z., "Order of the Red Banner of Labor" Institute of  
Cybernetics With Computing Center, UzSSR Academy of Sciences

[Abstract] An investigation is made of an acousto-optical deflector based on cubic crystals of gallium phosphide, which has a high value of acousto-optical quality  $M_2$ . Relations are given for determining the diffraction efficiency, maximum number of resolvable elements and acoustic frequency band of an acousto-optical deflector. The deflector cells proper were cubic GaP crystals measuring  $6.5 \times 10 \times 15$  mm cut along the crystallographic axis. The GaP crystal was welded to piezoelectric transducers in the form of X-cut lithium niobate plates measuring  $4 \times 8.5$  mm welded to an acoustic line by a layer of indium. Total thickness of the joining was no more than  $0.8 \mu\text{m}$ . After welding, the transducers were ground to a thickness of 33 and  $20 \mu\text{m}$ , corresponding to fundamental frequencies of 72 and 104 MHz. Measurements were made in the pulsed mode with a helium-neon laser light source and an electric oscillator for stimulating ultrasonic vibrations of the cell. On ultrasonic frequency of 71 MHz, the velocity of propagation of the ultrasonic wave is  $4.14 \cdot 10^5$  cm/s. The effective length of the acoustic column was found to be 0.6 cm, which differs from the actual size of the transducer, showing that the lithium niobate was not welded to the acoustic line over the entire surface. The efficiency of electric-to-acoustic signal conversion as evaluated by the intensity of the diffracted light was 20-25% on frequencies of 72 and 104 MHz. Diffraction maxima up to  $\pm 3$  orders were observed at zero angle of incidence and controlling electric power of 1 W. Diffraction efficiency is nearly independent of polarization of the incident light, and was 20% with frequency band at half-amplitude of 46 MHz for the 72 MHz transducer, and 15% with band of 49 MHz for the cell with natural frequency of 104 MHz. Time of passage of the acoustic wave front through the aperture of the light beam is  $3.6 \mu\text{s}$ . Figures 3, references 5: 3 Russian, 2 Western.

[232-6610]

## SUPERCONDUCTIVITY

### INSTABILITY OF NONEQUILIBRIUM STATE OF SUPERCONDUCTING FILMS OF NIOBIUM WITH TUNNEL INJECTION OF QUASIPARTICLES

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 34, No 2, 20 Jul 80 (manuscript received 15 Jun 81) pp 57-60

PAN, V. M. and RUDENKO, E. M., UkSSR Academy of Sciences Institute of Physics of Metals

[Abstract] A study has been made for the first time of superconducting films of niobium with the heavy tunnel injection of quasiparticles. Nb - I - Pb tunnel structures were produced which had low tunnel resistivity of  $(7 \text{ to } 9) \cdot 10^{-6} \Omega \cdot \text{cm}^2$ . The thickness of the Nb and Pb films was 200 and 500 nm respectively, and the area of the contacts was  $1 \cdot 10^{-4} \text{ cm}^2$ . Measurements were made of the current-voltage characteristics of the tunnel contacts and of the voltage in the niobium film in the region of the contact. When the current reaches a critical value of  $I_n$  voltage suddenly originates in the Nb film but a sudden drop in voltage is observed on the tunnel current-voltage characteristic. The local temperature  $T_l$  in the region of the tunnel contact was measured to make sure that the voltage arising in the niobium film was not the result of thermal transition of the film into the normal state. The instability point  $T_l^n$  represents the temperature of the tunnel structure at the moment of transition of the superconducting film into a new state as the result of instability. This temperature always remained considerably below the critical temperature for niobium films: 9.12 to 9.21 K. It was demonstrated conclusively that the origin of the new state is determined by instability of the nonequilibrium state of superconducting films under the heavy injection of quasiparticles. The uniform spatial distribution of a parameter on the order of  $\Delta_{Nb} \neq 0$  (where  $2\Delta_{Nb}$  is the energy gap of a film of niobium) becomes unstable with a temperature in the region of the contact of  $T_l < T_s$ , where  $T_l$  is the local temperature in the region of the contact when the injection current reaches a specific critical value of  $I_n$  and  $T_s$  is the superconducting transition point. The superconductor then goes into the normal or inhomogeneous state. Figures 2, references 4: 2 Russian, 2 Western.  
[250-8831]

UDC 533.922.01:621.372.853.3

INTERACTION OF MODULATED ELECTRON BEAM AND PLASMA WAVEGUIDE

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 26, No 6, Jun 81  
(manuscript received 30 Jun 80) pp 1036-1037

BALAKIREV, V. A., ONISHCHENKO, I. N. and TOLSTOLUZHSKIY, A. P., Physico-Technical Institute, UkSSR Academy of Sciences, Khar'kov

[Abstract] Steady-state interaction of an electron beam and a monochromatic high-frequency wave in a plasma waveguide is analyzed, the electron beam being density modulated at the frequency of the wave it amplifies as a result of this interaction. The equations of the steady-state process are written for a homogeneous plasma cylinder surrounded by a conducting sheath with the same radius and a modulated monoenergetic electron beam with a much smaller radius propagating inside through the waveguide in an external magnetic field with the lines of force parallel to the waveguide axis. The solution of these equations by numerical integration and typical data reveal that, as expected, the distance to the first amplitude peak of the wave decreases with increasing percentage modulation but almost without a change in the magnitude of the peak. The amplitude of the amplified wave thus reaches a saturation level sooner than in the case of a nonmodulated electron beam. Figure 1, references 4 Russian.  
[243-2415]

UDC 535.2

RADIATION OF PLASMA FORMED WHEN PULSE OF FAST PARTICLES ACTS ON FOIL IN VACUUM

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
No 3(127), May-Jun 81 (manuscript received 28 Apr 80) pp 14-18

DOBKIN, A. V. and NEMCHINOV, I. V., Moscow

[Abstract] The authors consider the question of the influence of radiation on gasdynamic processes, plasma parameters and characteristics of the resultant radiation pulse for the case of fast particles interacting with a barrier. The analysis is based on direct solution of the corresponding one-dimensional planar unsteady gasdynamic radiation problem. Consideration is taken of the spectral

makeup of the radiation. The barrier is a foil sheet of thickness such that part of the radiation goes beyond the foil, i. e. in the direction of beam propagation. Specifically, a proton pulse is assumed to interact with an aluminum barrier in vacuum. Proton energy varies in a range of from 100 keV to 1 MeV. Energy flux density is constant in time and equal to  $1-10 \text{ GW/cm}^2$ . For pulse durations of  $0.1-1 \text{ } \mu\text{s}$  and dimensions of the irradiated spot of the order of  $1-3 \text{ cm}$ , the vapor is dispersed under conditions close to plane geometry. Electrostatic effects were disregarded, as it was assumed that the proton beam was neutralized by electrons. Thus essentially this analysis applies to the action of a quasineutral hydrogen plasmoid on a barrier, but with consideration of injection of fast particles into the material of the target and vapor, rather than in the purely hydrodynamic approximation. Analysis of the emission spectra shows that an appreciable part of the beam energy may be converted to radiation. The radiation emitted in the reverse direction is  $1 \frac{1}{2}$  times as intense as the forward emission, and has an appreciable contribution from quanta with energies up to 150 eV. Such quanta are nearly absent in the forward emission due to the filtering action of a heated layer with temperature of 5-7 eV. The emission spectrum of the plasma can be controlled by pulse parameters, foil thickness and the optical and thermodynamic properties of the foil material. A similar effect of emission to both sides of a foil should be observed with other fluxes such as electron or laser beams. Figures 3, references 10 Russian.  
[237-6610]

UDC 519.63

#### EVOLUTION OF LOW-TEMPERATURE LASER PLASMA IN HIGH-PRESSURE NITROGEN ATMOSPHERE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 257, No 3, 1981  
(manuscript received 27 Oct 80) pp 584-589

MAZHUKIN, V. I., UGLOV, A. A. and CHETVERUSHKIN, B. N., Institute of Applied Mathematics imeni M. V. Keldysh, USSR Academy of Sciences, Moscow

[Abstract] Numerical modeling methods are used to determine and analyze the particulars of development of a laser plasma close to a solid surface in nitrogen at a pressure of 30 atmospheres. The modeling is based on a system of two-dimensional equations of unsteady radiative gas dynamics in Lagrangian variables, where self-radiation is described in the multigroup diffusion approximation. The stage of optical breakdown of cold nitrogen is modeled by assignment of a hot region along the  $r$ -axis close to the surface on which laser radiation is incident along the  $z$ -axis. The results of numerical modeling showed that in the early instants up to  $0.1 \text{ } \mu\text{s}$ , the development of plasma formations is analogous to plasma development at 100 atmospheres. Laser radiation is absorbed mainly in the hot region, generating a supersonic shock wave into the cold gas. Expansion of the hot region is initially one-dimensional along the  $z$ -axis. During this period, the region next to the surface remains almost unheated. After this period, the hot region expands to the point where it becomes transparent to laser emission, and by  $0.3 \text{ } \mu\text{s}$ , the rate of dispersal of the hot region reaches a maximum of about



1.1 km/s, which is greater than the shock wave velocity of 0.75 km/s. There is no second shock wave since the region expands into much less dense material, although the compaction of matter in the shock wave continues to increase up to 0.4  $\mu$ s. The temperature in the shock wave region reaches a maximum of 3.6 eV by 0.18  $\mu$ s, and then falls to 2.0 eV at 1  $\mu$ s due to de-excitation and reduction of absorbed radiation. The temperature of the region near the surface at first decreases due to gasdynamic dispersal, and then as transparency increases it is heated by laser emission to a maximum of 3.6 eV at 0.49  $\mu$ s. Then with decreasing density and increasing transparency, the temperature of the hot region begins to fall and more of the laser radiation goes to heating the target. The shock wave rapidly damps out, leaving subsonic perturbations in its wake within 1  $\mu$ s. An analysis of the relative contributions of gasdynamic and radiative mechanisms of energy transfer shows that gasdynamic processes predominate up to 0.2  $\mu$ s. At 0.3  $\mu$ s the situation begins to change, and by 0.8  $\mu$ s gasdynamic processes make no appreciable contribution. However, as time goes on the radiant fluxes also decrease due to falling temperature in the hot region. The power of laser emission necessary for maintaining plasma development is practically independent of pressure. Threshold power was 92 kW at 30 atmospheres, just as at 100 atmospheres. Figures 4, references 6 Russian. [233-6610]

UDC 937.568

# ELECTRON-BEAM HEATING OF PLASMA AND PARTICULARS OF IONIZATION MECHANISM IN UNSTEADY KNUDSEN ARC

Moscow FIZIK. PLAZMY in Russian Vol 7, No 3, May-Jun 81 (manuscript received 20 Mar 80) pp 547-559

BAKSHI, F. G., BOGDANOV, A. A., KAPLAN, V. B., KOSTIN, A. A., MARTSINOVSKIY, A. M. and YUR'YEV, V. G., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] An analysis is made of some experimental results found in the investigation of unsteady processes in a Knudsen arc plasma. The studies were done in a cesium discharge arc at pressures of 0.005-0.05 mm Hg. Both the conventional two-electrode system and a three-electrode arrangement were used. In the three-electrode setup, the grid between anode and cathode could be controlled to vary discharge current. The electrodes were the ends of hollow molybdenum cylinders about 10 mm in diameter, giving radial homogeneity of the discharge plasma with relatively small edge effects. The cathode was heated to 1000 K, providing thermionic emission of about 1 A/cm<sup>2</sup> in the cesium vapor. Probe diagnosis and spectroscopy were used for determining plasma parameters. The experimental technique enabled registration of weak electric and optical signals with time resolution of about 20-50 ns. An analysis is made of the mechanism of burning of a short Knudsen arc at high voltages across the discharge gap when the energy transferred by a cathodic beam to the thermal electrons through electron-electron collisions is insufficient for heating them. The results show that under these conditions

the heating of the thermal electrons is due to collisional damping of Langmuir waves stimulated by the electron beam, while atoms are ionized by the heated thermal electrons. A system of equations is derived that describes arc behavior. The proposed mechanism of plasma heating by excitation and subsequent relaxation of Langmuir waves can explain the principal peculiarities of burning of a short Knudsen arc at high voltages or low plasma concentrations. Figures 6, references 23 Russian.

[227-6610]

UDC 533.951

#### SUFFICIENT CRITERION FOR ION BEAM SYSTEM STABILITY

Moscow FIZIKA PLAZMY in Russian Vol 7, No 3, May-Jun 81 (manuscript received 18 Aug 80) pp 573-574

CHERNYAKOV, A. L., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] Systems containing directed ion fluxes are frequently encountered in plasma physics. Although the stability of such systems relative to buildup of potential electric oscillations has been thoroughly analyzed, no simple analytical criteria of stability have been derived. In this paper the author derives such a sufficient stability criterion for a system that contains an arbitrary number of ion streams. It is assumed that all directed velocities are less than the thermal velocity of electrons. The final expression takes the form

$$\frac{n_e}{T_e} > 0.3 \sum_{i=1}^N \frac{n_i}{T_i},$$

which in the case of two identical ion streams becomes  $\frac{T_i}{T_e} > 0.3$ . References 4: 2 Russian, 2 Western.

[227-6610]

UDC 537.521

#### PRESSURE PULSATION DUE TO SUPERHEATING INSTABILITY IN INTENSE ARC DISCHARGE

Moscow FIZIKA PLAZMY in Russian Vol 7, No 3, May-Jun 81 (manuscript received 20 Mar 80, after revision 28 Apr 80) pp 583-586

KIM DIN CHER, Institute of Thermal Physics, Siberian Department, USSR Academy of Sciences

[Abstract] An investigation is made of the influence that plasma column compression by the magnetic self-field of axial current has on the characteristics of an argon arc in the region of parameters that correspond to superheating instability. The analysis shows that superheating instability is accompanied by abrupt changes in the gas-kinetic pressure of the plasma. Different temperature distributions correspond to the same values of current and electric field strength. An N-type or S-type branch shows up on the current-voltage curve of the arc depending on the diameter of the plasma column. It is shown that a lengthwise homogeneous

discharge may burn throughout the range of axial temperatures. Radial distributions of temperature, pressure, magnetic field and current density are given. Figures 5, references 11: 8 Russian, 3 Western.  
[227-6610]

UDC 533.521

#### HIGH-PRESSURE GAS BREAKDOWN IN ELECTROMAGNETIC WAVE FIELD

Moscow FIZIKA PLAZMY in Russian Vol 7, No 3, May-Jun 81 (manuscript received 21 Oct 80, after revision 4 Dec 80) pp 604-608

ARUTYUNYAN, S. G., IGNAT'YEV, A. V. and RUKHADZE, A. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Breakdown of a high-pressure gas is considered in the average electron model in the field of a strong electromagnetic wave where both the effective frequency of electron collisions is in comparison with the average chaotic energy, and the average frequency of ionization of atoms are greater than field frequency. Numerical solution of the relativistic equation of electron motion in the wave field gives the dependence of the constant of cumulative gas ionization on field amplitude. It is found that as field amplitude increases, this parameter at first decreases, and then reaches a nearly fixed level. This behavior is a consequence of similar dependence of the frequency of inelastic collisions on velocity, which also approaches a nearly constant value as velocity approaches the speed of light. Figures 4, references 6: 5 Russian, 1 Western.  
[227-6610]

UDC 533.932

#### INVESTIGATING PLASMA CONCENTRATION IN ELECTROMAGNETIC TRAP

Moscow TEUFLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 3, May-Jun 81 (manuscript received 21 May 80) pp 614-618

KOMAROV, A. D., LAVRENT'YEV, O. A., POTAPENKO, V. A., SKIBENKO, A. I., STEPANENKO, I. A. and FOMIN, I. P., Kharkov Physicotechnical Institute

[Abstract] In the past, there has been satisfactory agreement between theory and experiment with regard to plasma concentration as a function of magnetic field strength in the vicinity of an annular slot and an axial aperture. However, previous experiments have been done in comparatively weak magnetic fields. In this paper, the authors study the magnetic field dependence of plasma concentration in strong fields and at high blanking voltages. An analysis is also made of the

plasma concentration profile in an electromagnetic trap. The experiments were done on the Jupiter-1A facility shown in the diagram. Measurements were made by a non-contact microwave technique using a long-line interferometer with modulation of the working frequency. Probe signal wavelengths were 8 and 13 mm. It was found that plasma concentration in the center of the electromagnetic trap is more than an order of magnitude higher than the average. Apparently the plasma is concentrated in the region of nonadiabatic particle motion.

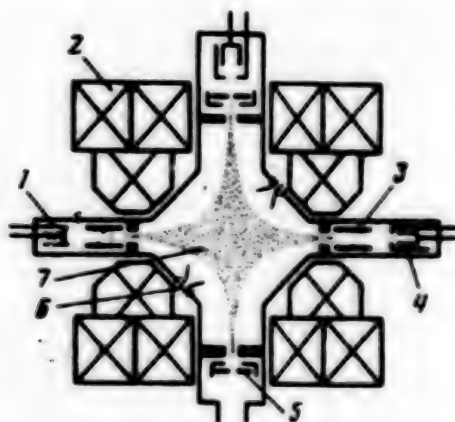


Diagram of electromagnetic trap:

- 1--electron gun;
- 2--magnetic field coils;
- 3--axial-orifice electrostatic cutoff device;
- 4--axial orifice collector;
- 5--annular-slot electrostatic cutoff device;
- 6--microwave antennas for plasma diagnosis;
- 7--plasma formation

Figures 5, references 9: 7 Russian, 2 Western.  
[224-6610]

#### MULTIBEAM SELF-CHANNELING OF PLASMA WAVES

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 80,  
No 6, Jun 81 (manuscript received 21 Nov 80) pp 2264-2271

MARKOV, G. L., MIROMOV, V. A., SERGEYEV, A. M. and SOKOLOVA, I. A., Institute of  
Applied Physics, USSR Academy of Sciences

[Abstract] Practical use of the effect of self-stress of electromagnetic waves in plasma frequently involves the feasibility of directed and localized transfer of field energy to charged particles. The authors investigate one of the most appropriate physical effects for this purpose: self-channeling of plasma waves in the lower hybrid frequency band  $\omega_{H1} < \omega < \omega_{He}$  ( $\omega_{He}$ ,  $\omega_{H1}$  are the electronic and ionic cyclotron frequencies respectively) under conditions of ionization nonlinearity. The experimental facility is described in an earlier paper by G. A. Markov et al, [see FIZIKA PLAZMY, Vol 6, 1980, p 670]. The rf discharge



was excited in a glass envelope by cylindrical, dipole and quadrupole inductors at frequency of 60 MHz and power from 0 to 300 W. Air was the working gas at a pressure of 0.01 mm Hg or less. The discharge took place in a magnetic field with induction of 500 Gs with inhomogeneity of no more than 6% along the axis of the system. The structure of the rf potential in the plasma was taken by a shielded rod antenna connected either to an S4-27 analyzer or to an S7-8 high-speed oscilloscope, enabling determination of the excited plasma wavelength from the phase difference of the waveforms at different points of the system. Single and double moving Langmuir probes were used for plasma diagnosis. The major result of the experiment was detection of a mode of steady-state multibeam wave channeling in the magnetic field, considerably different from the analogous effect in an isotropic plasma and condensed media. A theoretical model is proposed that demonstrates the existence of multiple-soliton solutions elucidating the most typical features of the observed effect. Figures 7, references 10: 6 Russian, 4 Western.

[223-6610]

UDC 533.9.07

#### ION STREAMS WITH OUTFLOW OF DENSE PLASMA INTO VACUUM FROM CYLINDRICAL ORIFICE

Minsk IZVESTIYA AKADEMII NAUK BSSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 3, May-Jun 81 (manuscript received 11 Dec 80) pp 61-65

ANTONOV, G. S., KISELEVSKIY, L. I., RABZONOV, P. G. and SHKURKO, V. V., Institute of Physics, BSSR Academy of Sciences

[Abstract] By exposing various targets to intense laser beams, ion streams can be generated with a wide range of energies. The maximum energy of ions dispersing into vacuum may considerably exceed their thermal energy, which is an indication of the development of acceleration processes during plasma dispersal. Previous research has shown that these processes result in two maxima in the energy distribution of ions corresponding to "thermal" and "accelerated" particles. One of the main problems in designing a laser-plasma injector is to reduce the angle of dispersal of ions to maximize efficiency of utilization. Plasma dispersal is close to hemispherical when laser emission is focused on a flat target, and the ions are ejected into the same hemisphere from which the beam is incident on the target. In this paper the authors consider the feasibility of decoupling the ion stream from the laser emission by opening a second channel for plasma dispersal with laser radiation focused into a fine hole drilled through the target rather than on the flat surface. Aluminum targets were used, and the capillaries were made L-shaped with equal arms of 3 mm and diameter of 1 mm. The density of the laser radiation was  $10^{10}$  W/cm<sup>2</sup>, and pulse duration at half-amplitude was 50 ns. The target was placed in a vacuum chamber ( $2 \cdot 10^{-5}$  mm Hg). Emission was focused on one arm of the capillary, and the axis of the other arm passed through the center of a collimating slit and coincided with the axis of the charged particle collector, a photomultiplier of open type. Analysis of the results shows that the difference between the "thermal" and "accelerated" components

of the energy spectra of ions in a plasma stream with density of about  $10^{19} \text{ cm}^{-3}$  shows up most strongly in the axial and perpendicular directions, practically disappearing at intermediate angles. It is shown that energy may be transferred from the fast ions to the slow ions in the vicinity of the capillary walls.

Figures 4, references 8: 7 Russian, 1 Western.

[222-6610]

UDC 621.384.659:533.9.12

#### OPERATING PARTICULARS OF EXPLOSIVE-EMISSION MULTIPOINT CATHODES IN MICROSECOND PULSE RANGE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 6, Jun 81  
(manuscript received 26 May 80) pp 1183-1194

VASILEVSKIY, M. A., ROYFE, I. M. and ENGEL'KO, V. I.

[Abstract] Previous research on the properties of multipoint explosive-emission cathodes with microsecond pulse duration have shown that these cathodes can be used to get electron beams of large cross section with duration of tens and hundreds of microseconds. However, operation at long pulse durations has a number of differences from nanosecond pulse operation. For one thing, the average rate of expansion of the cathode plasma during a pulse may be slower than in the nanosecond range depending on the material of the points and the voltage pulse shape. The rate of plasma expansion is minimized when the points are made of graphite. When a Marx generator is used as the high-voltage pulse source with current density of about  $1 \text{ A/m}^2$ , there is little change in the rate of plasma expansion over most of the pulse. The rate of expansion decreases with a reduction in the amplitude of the accelerating pulse. In the second place, there may be a considerable difference in current oscillograms from one pulse to another at pulse durations of greater than  $10^{-5} \text{ s}$  when graphite points are used: the diode current may fall off smoothly, or fall off with isolated spikes, or rise abruptly after maintaining a flat level for a few microseconds, and then drop, or else fall off with high-frequency fluctuations and spikes. Spikes and abrupt changes are almost completely eliminated by connecting resistors of about 1000 ohms in the circuit of each cathode point, and using a backing under floating potential. Thirdly, experiments with a cathode 21 cm in diameter where the diode current changes smoothly in time show symmetric distribution of current density in the radial and azimuthal directions with maximum in the central region. The authors discuss the possible causes of these effects, and show that the experimentally observed time dependence of current-voltage characteristics of the diode can be explained by assuming that two factors contribute to the expansion of the cathode plasma: an increase in the number of particles due to vaporization of points, and a reduction in the voltage across the accelerating gap. It is also shown that at a beam current density of  $1 \text{ A/cm}^2$  or more, the particle concentration distribution over the cross section of the cathode plasma has a considerable influence on expansion. This can be attributed to the experimentally observed instability of diode operation at long pulse durations. Methods are discussed for preventing the disruption of homogeneity of distribution of cathode plasma concentration. Figures 6, references 23: 19 Russian, 4 Western.

[221-6610]

## THEORETICAL PHYSICS

UDC 533.9

### NUMERICAL REALIZATION OF ONE-DIMENSIONAL MODEL OF RELATIVISTIC ELECTRON BEAM IN WAVEGUIDE

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 15: VYCHISLITEL'NAYA MATEMATIKA I KIBERNETIKA in Russian No 2, Apr-Jun 81 (manuscript received 13 Oct 80) pp 17-22

FILIPPYCHEV, D. S.

[Abstract] The author considers a one-dimensional model of motion of a relativistic electron beam in a coaxial waveguide made up of two cylinders of given radii with a given potential difference set up between them. Such a device can produce beam configurations with electron layers separated either by vacuum gaps or by regions with an ionic background. In this paper a beam configuration is considered such that the annulus between electrodes contains a single electron layer filling the entire working space. It is shown how this condition can be met for zero initial velocities of the particles. An efficient scheme is proposed for numerical solution of the problem and some results are given. It is shown how the method can be extended to the case where the waveguide is only partly filled by the electron beam. Figures 3, references 2 Russian.  
[210-6610]

UDC 517.958:535.4

### NONLINEAR PROBLEM OF WAVE DIFFRACTION BY BOUNDED SOLID

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 21, No 3, May-Jun 81 (manuscript received 30 May 79, after revision 9 Jan 80) pp 731-736

PAVLOV, A. L., Moscow

[Abstract] An examination is made of the external scalar two-dimensional steady-state problem of wave diffraction by a bounded solid. It is assumed that the nonlinear medium outside of the body is characterized by an index of refraction that depends on spatial coordinates and field amplitude, and that is constant

outside of a circle of large radius with center inside the solid. It is assumed that wave sources are situated on the boundary of the solid and in the region between this boundary and the circle. Sufficient conditions are found for the correctness of the diffraction problem and strong convergence of Galerkin approximations to the exact solution in Sobolev space  $H^1$  for media in which the index of refraction is a function that is finite with respect to time, and that have fairly large absorption. References 3 Russian.  
[248-6610]



UDC 519.3:62-50

LINEAR PROBLEM OF PURSUIT BY SEVERAL PURSUERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 258, No 2, 1981  
(manuscript received 29 Dec 80) pp 275-279

GRIGORENKO, N. L., Moscow State University imeni M. V. Lomonosov, presented by  
academician L. S. Pontryagin 15 Dec 80

[Abstract] A single fleeing object is pursued by several controlled pursuers. The concept of the first direct pursuit technique of L. S. Pontryagin [DOKLADY AKADEMII NAUK SSSR, Vol 174, No 6, 1967] is used to derive the sufficient conditions for completing the pursuit game from the specified initial positions in a finite time under conditions which allow for the study of the game with players having both the same and different response inertias. An equation is written for the motion of an arbitrary number of vectors in  $n$ -dimensional Euclidean space; a differential game with several players is then described in which the control vectors of the pursuers and the pursued are defined. The pursuit problem is formulated to determine the game parameters for which there exists a pursuit strategy for the specified initial conditions that at least one of the pursuit vectors is successful. The relevant propositions are stated and proved and applied to the example of a simple differential game with two pursuers to illustrate the conditions under which the pursuit game is resolvable from all initial positions. M. S. Nikol'skiy reviewed the work. References 13 Russian. [215-8225]

UDC 62-50

DYNAMIC GAMES WITH FIXED DURATION

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 45, No 2, Mar-Apr 81  
(manuscript received 23 Jan 80) pp 230-235

TOMSKIY, G. V., Yakutsk

[Abstract] Let there be a time segment  $[t_0, T]$ , a set of states  $X$ , sets  $U$  and  $V$ , and a set of controls  $D_1$  ( $D_2$ ) of the first (second) player with elements that map time segment  $[t_0, T]$  into  $U(V)$ , and a state function

$K: [t_0, T] \times [t_0, T] \times X \times D_1 \times D_2 \rightarrow X$ . The author considers two-player dynamic games  $\Gamma(t_*, x_*)$  described by the dynamic system  $\Sigma = ([t_0, T], X, D_1, D_2, K)$  with certain conditions in which the advantage of the first player takes the form  $I(u, v, t_*, x_*) = H(K(T, t_*, x_*, u, v))$  where  $H: X \rightarrow R^1$ . It is assumed that this functional is maximized by the first player and minimized by the second, using piecewise-programmed strategies. Four successive approximation methods are examined for determining the value of the game with construction of  $\epsilon$ -optimum strategies. The convergence of these methods is proved by using piecewise-programmed strategies. References 10: 8 Russian, 2 Western.  
 [218-6610]

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